MODERN FARM MACHINERY

BY

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N.D.A., A.I.A.E.

WITH INTRODUCTION BY

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FOREWORD

AGRICULTURE to-day is seeking a way out of the troublous times in which it finds itself and to which it has drifted owing to the apparently greater importance of manufacturing industries, through the apathy of the urban population as to its well-being and its influence on the prosperity of the country. Some look to Government for assistance, but wiser men see that salvation must come from within the industry and are striving to discover and introduce improved methods of production and of marketing.

This book deals mainly with mechanical aids to production and to a certain extent, transporting machinery, and is of considerable value, as it is written by one who has had an extensive practical experience of working with agricultural machinery and so can envisage the matter from the farmer's point of view.

The object of the successful captain of industry and we can so designate the farmer, is to increase the output per man employed in his factory or on his farm and one method by which this output can be increased is by giving the workman the best labour-saving machinery for the required purpose. A man with a spade can dig an acre in two or three weeks—give him a plough and a team and he can plough an acre in a day—give him a tractor and his output can be four or five acres a day. The sickle is superseded by the reaper and binder and the flail by the threshing drum, and the output per man is increased thereby. Not only is the output increased, but the operations are carried out more quickly, which in our changeable climate is of the greatest importance in both cultivation and harvesting operations.

But it is not sufficient to give the man the machine. Someone on the farm must have an adequate knowledge of the construction, of the wearing parts, of the reasons for breakdowns, and this "someone" should be the farmer. A stoppage necessitating outside advice and the transport of the machine to the nearest repair shop means the loss of valuable time and the loss of the farmer's temper, as he is too apt to blame the machine or the workman when the blame should be on himself for either not being thoroughly conversant with the details of the implement or being unwilling to pay such a wage as would secure a workman expert in such knowledge.

The ordinary farm labourer is generally an implement "butcher" and the skilled mechanic is objected to by the farmer, as he is often loth to lend a hand in the ordinary work of the farm when his services are not required with the implements. It would pay many farmers who have no knowledge of, and often an aversion to, machinery and who have in use a number of implements, tractors, etc., to keep a mechanic whose time would be fully occupied in repairs of and attention to the implements, both when they are working and when they are not in use.

The selection of the implements and the prospects of their being of economic value on the farm are matters for the farmer to decide, but if he has a mechanical knowledge, such as is imparted by this book, he will, when inspecting a machine, be able to form an opinion as to its value for his conditions, from a mechanical, as well as from a farming standpoint.

It has been said that chemistry and engineering were of supreme importance in the conduct of the Great War, and it can be repeated without exaggeration that these two sciences are also of supreme importance in carrying on the business of agriculture. A farmer need not be a skilled engineer or chemist, but his preliminary training, wherever it may be given, on a farm or at a college, should include a working knowledge, as far as his own industry is concerned, of these sciences.

The aim of this book is to be practically informative, and a study of its contents, coupled with a reference to the actual implements, may be the means of saving much time and money to the farmer and at the same time may add to his and his men's efficiency in production on economic lines. The learner, agricultural student or pupil, should thoroughly master its contents before he commences business.

An agricultural prophet has foretold that the agricultural workman will in the future be a man " to mind machines." This, of course, is an exaggeration, as many operations, both on the land and with stock, must always require the personal touch of the skilled human worker; but the use of machinery has increased to a very large extent during the last few years, and it is only by the intelligent and sympathetic use of such machinery that a successful result can be secured

M. J. R. DUNSTAN

PREFACE

THE attention given to agricultural engineering by educational institutions has been very limited in the past, and even to-day there is no specialized course of training in the subject in this country. Consequently, there is practically no co-ordinated information available for the student or the user of farm machinery. It is agreed on all sides that machinery must play a more important part in production as time goes on, for, while labour costs must be reduced wages must be increased. The net result is that both master and men must be prepared to use every labour-saving device available so that a man may be able to earn more money by his increased output, and the master increase his profits by reducing production costs.

It is useless, however, for a farmer to invest money in machinery which he does not understand or is not prepared to attend to properly. He will only multiply his losses.

The object of this book is to set out in plain language the principles of construction, the uses, and the operation of modern types of machines in use on farms to-day. The bulk of it is based on the practical experience of the writer, who hopes that it will prove of service to the student, the farmer, and the agricultural engineer.

The thanks of the author are due to the numerous manufacturers who have materially helped in the production of the book by the loan of illustrations, and to the Editor of "The Agricultural Gazette and Modern Farming" for his permission to reproduce a number of photographs.

D. N. McHardy

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MODERN FARM MACHINERY

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CHAPTER I

MECHANICAL PRINCIPLES EMPLOYED IN FARM MACHINERY

MOST implements are built up of a number of mechanical devices which work together. In nearly all cases the principle upon which these work is easily traced back to two elementary machines—the lever and the inclined plane. Machines for practical purposes are used to overcome resistance, and are nearly always arranged so that the force applied by the prime mover is magnified. This increase is known as the mechanical advantage of the machine. If the resistance overcome is R and the power applied is F the mechanical advantage is represented by the ratio RF. The lever consists of a rigid bar, capable of turning about a point in its length, known as the fulcrum. There are three classes of levers, examples of which are shown.

The chief application of the inclined plane is in the screw, the thread of which belongs to this class of machine.

Although the employment of these machines increases the force derived from the prime mover, yet the actual work done by the latter is always the same. The term work is applied when a force acts at a point and moves that point in the direction of application of the force.

The unit of work is the foot lb. and equals the raising of one lb. through a vertical height of one foot.

Power is the rate of work, the unit of which is the horse power, 1 h.p. being equal to 33,000 foot lb. per minute.

The action of a machine giving a mechanical advantage is to increase the force of the power applied by making it act through a greater distance.

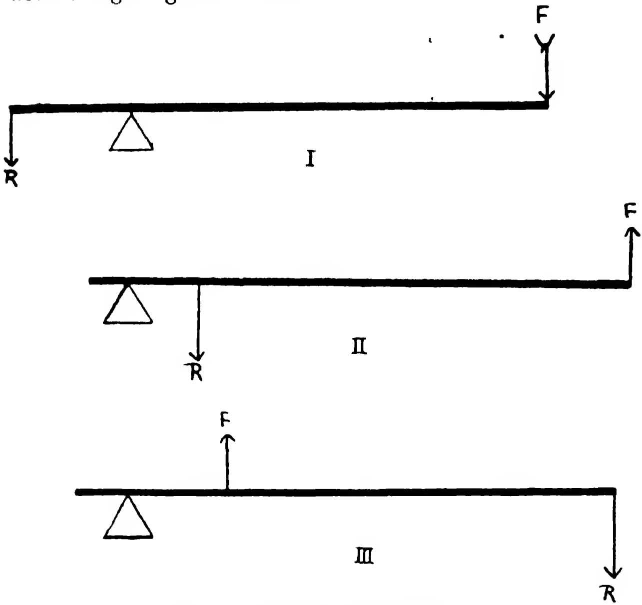


Fig. 1 The three classes of lever
I and II show a mechanical advantage, and III a disadvantage.

In the transmission of power on agricultural machines many instances of the application of these principles can be observed. In the case of implements having moving parts, the motive power for operating these is usually taken from the land wheels. The latter obtain their motion as a result of the implement being hauled along; but as they have a resistance to overcome in driving the moving parts of the machine, it is necessary to equip them

with some form of lug or strake on the rims, to enable them to get traction. Without these strakes the wheels would skid, unless the machine were excessively heavy.

As it is not desirable to have the moving parts running when the machine is not working, the drive from the land wheels is usually taken through a clutch. This is a simple

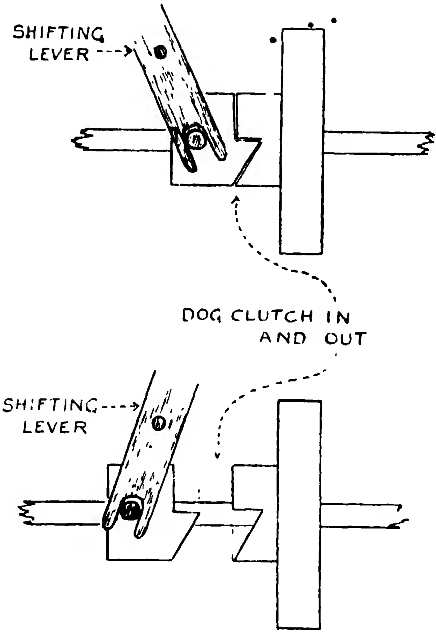


FIG. 2

connexion, which can easily be made or broken at will, to put the machine "in gear" or "out of gear." In most cases a dog clutch is used. In Fig. 2 a driving gear is mounted loosely on a driving shaft. The dog clutch is mounted on a portion of the shaft which is square in section. It is capable of sliding along the square shaft, but must always turn with it. When the dogs on the clutch and

those on the gear are engaged, the shaft drives the gear through the dogs and the machine is in gear. When the dogs are slid out of engagement, the shaft runs idly inside the gear and the machine is out of gear.

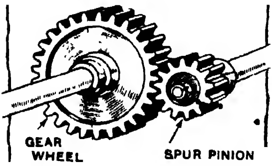


FIG. 3A

On some engine hoists friction clutches are employed, which act through two friction members which are forced together by a spring. This permits of gradual engagement, whereas the dog clutch is positive in action and must be usually engaged when the machine is at rest.

Power may be transmitted from one shaft to another by means of various types of gears.

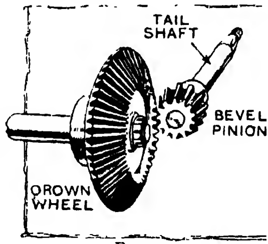


FIG. 3B

These include spur gears, in which the teeth are parallel to the axis of the gear wheel; bevel gears, where the teeth are at an angle; and worm gears. Bevel gears are employed to transmit power where the two shafts are at an angle to one another, while a worm gear can also drive a worm wheel on a shaft at right angles to it. In gear drives the speed of the driven shaft can be made greater or less than that of the driver, by making the two gears with a different number of teeth. The relation between the two is known as the gear ratio.

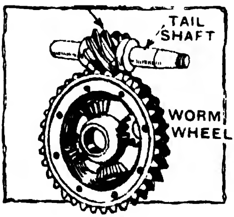


FIG. 3C

Where the driver has a small number of teeth and the driven many, the speed of the driven shaft is less than that of the driving shaft and the force available is proportionately increased.

Chains may be employed to transmit a drive between two shafts far apart, or from a wheel to a shaft. The

chain links engage with the teeth of the sprockets, which are mounted on the shafts to take the drive. The same rule as to the gear ratio applies in this case, being reckoned on the sprocket teeth.

In belt driving we have pulleys and an endless belt in place of the sprockets and chain. This drive depends on the friction between the pulleys and belt. The speed ratio is determined by the relative sizes of the pulleys.

Any rotating piece of shafting has to run in bearings,

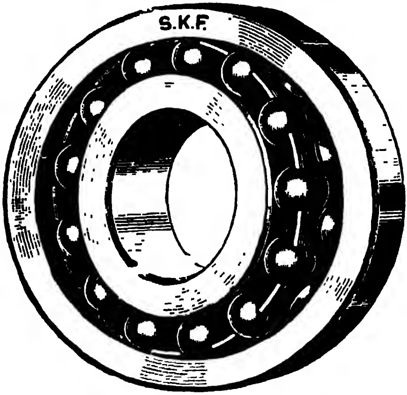


FIG. 4. Double row ball bearing (self-aligning)

the construction of which is determined by the nature of the work done by the shaft. Bearings on farm machines belong usually to one of three classes: plain, ball, or roller. These are designed to take radial or thrust loads. Radial bearings simply support the shaft in place, but thrust bearings have to be employed where there is a pressure in the direction of the axis of the shaft, due to a drive at right angles or some other reason.

In situations where plain radial bearings are subject to much wear they are usually constructed in two halves and provided with means for taking up the wear. The upper and lower halves are bolted together, and packing

or "shims" used between the two. These may be removed when it is necessary to take up wear, and so bring the two halves closer together. These bearings are generally lined with anti-friction metal. Plain thrust bearings are

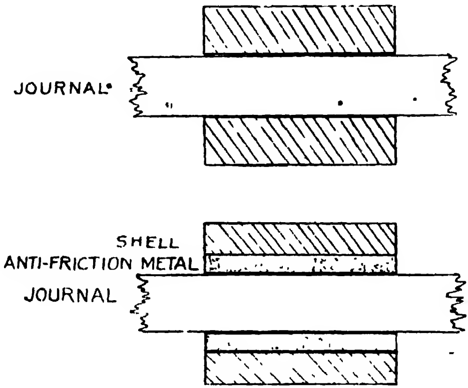


FIG. 5. Two types of plain bearing

usually made of very hard chilled iron, and consist simply of a cap bearing on the end of a shaft or on a collar fixed to it, thus preventing longitudinal movement.

Ball bearings are employed to reduce the friction which

FIG. 6. Ball thrust bearing

is experienced in the case of plain bearings. A simple ball bearing for radial loads consists of an inner and an outer race, and a cage holding a number of polished hard steel balls between the two. The races are a push fit on the journal and in the bearing, the only friction being between the balls and the races. In a self-aligning ball

bearing the inner and outer races are capable of tilting relatively to one another, while the balls are still held in the correct position. This allows of the shaft getting out of line without affecting the bearing. Ball thrust bearings comprise two thrust washers, between which the

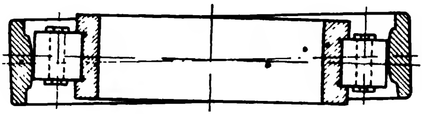


FIG. 7. Single row self-aligning narrow roller bearing

balls are held by a cage. Any pressure parallel to the shaft is taken between the balls and the washers.

Roller bearings are frequently employed in a long bearing which would require two sets of ball bearings. The rollers give line contact instead of point contact, as in

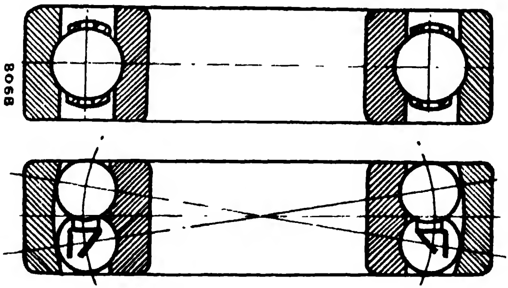


FIG. 8. Single row radial ball bearings, self-aligning and fixed

the case of balls. The rollers are usually held by a cage at each end, the two cages being joined by long rivets. These bearings are used to a considerable extent in mowing machines. The tapered roller bearing presents special advantages in being able to sustain thrust as well as radial loads, and is adjustable.

It is frequently necessary to convert reciprocating

(to and fro) motion to rotary motion, or vice versa, and for this purpose either the crank or the eccentric is employed in the transmission. A crank shaft has one portion offset by means of right angle bends, in order to provide a crank pin parallel to the main portion of the shaft. If a connecting rod moving in a to and fro direction has

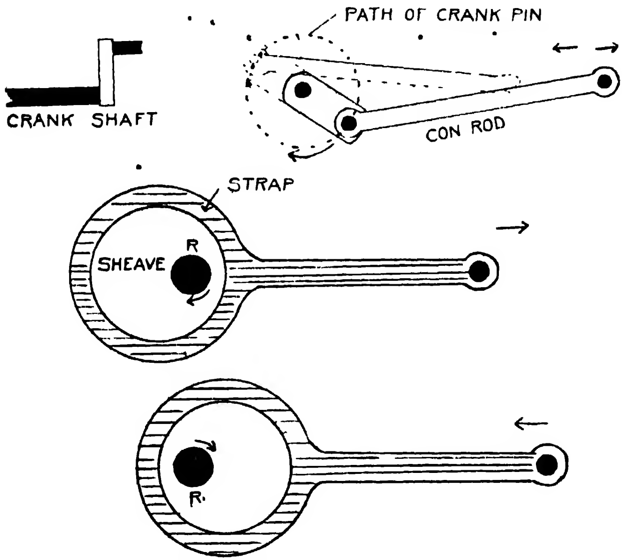


FIG. 9 The conversion of rotary to reciprocating motion by means of the crank and the eccentric. R is the section of shaft

one end connected to the crank pin the shaft will be rotated.

An eccentric is a circular plate mounted on a shaft in such a way that the centres of the shaft and of the disc are not coincident, as illustrated above. Around the eccentric passes a band known as the eccentric strap, to which is attached a connecting rod. As the shaft rotates a reciprocating motion is imparted to the strap and rod. The plate is known as the sheave.

Cams are usually heart- or pear-shaped pieces of metal fixed on a rotating shaft in order to impart a reciprocating motion to some part in contact with the surface of the cam. The part operated is held by a spring and thus made to follow the outline of the cam. Thus, at one period it comes closer to the shaft than at others. By varying the shape of the cam the part operated can be made to describe more complicated motions. This is made use of in internal combustion engines for valve operation, and also in the knotter of the binder.

Various types of link work are employed in machines

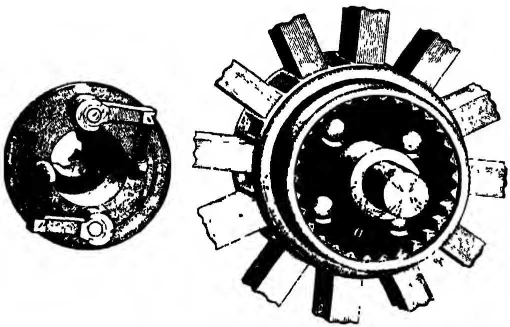


FIG. 10. Ratchet and pawl gear, as applied in Massey-Harris drill wheels

such as the potato digger and the hay tedder and side delivery rake. In the digger and the side rake the sweeping motion of the tines is obtained by mounting them on links joined at their ends to two reels set with their centres obliquely to one another. In the tedder, where a kicking action is required, the forks are mounted at their centres on cranks, while the travel of the upper ends of the forks is circumscribed by the loose links to which they are attached. A similar action occurs in the case of the packers on the binder.

In the case of implements which are driven from both land wheels it is necessary to allow for over-running of the

wheels when turning, since the outer wheel makes a larger turn than the inner. This is usually effected by a ratchet and pawl gear. The inner side of the hub is furnished with ratchet teeth, while two or three pawls are loosely mounted on the axle, in such a way that forward movement of the wheels drives the axle through the pawls. Backward movement of the wheels allows the pawls to slip past the ratchet teeth without being driven. The pawl and ratchet are also sometimes used as a driving gear, converting reciprocating to rotary motion. In this case the ratchet gear is mounted on a shaft, while the pawl is driven by a connecting rod. By altering the travel of the connecting rod a variable speed gear can be obtained.

CHAPTER II

MATERIALS AND METHODS USED IN THE CONSTRUCTION OF FARM MACHINERY

CAST iron is the form in which iron is first obtained from the ore, the molten metal coming from the furnace being run into moulds to form "pigs." Pig iron may be grey or white, the latter being harder, more brittle, and less fusible than the former. White iron is used for conversion into wrought iron and steel, and grey iron chiefly for castings.

Cast iron is brittle in character, strong in compression, but weak under tensile (pulling) stresses. It is easily fractured by a sudden shock. Parts of machinery which are complicated in shape are usually made of cast iron. Castings should be of uniform thickness, as far as possible, and angles should be reinforced by webs or fillets. Any abrupt variation in the shape of a casting is liable to cause weakness. Castings are made in the foundry by running molten pig iron of varied composition into moulds made in sand to the correct shape of the finished article by means of wood patterns. Once the pattern is made any quantity of castings can be turned out comparatively cheaply.

Chilled castings are hardened on the outside. The metal is run into iron moulds painted with loam on the inside. This cools the casting very quickly, and the outer layer becomes very hard and white, the inner layer being grey.

Malleable castings are made by placing the casting in a box full of oxide of iron and baking at a white heat. The outer layer loses carbon and is converted into wrought

iron. This process renders the part much tougher than the ordinary casting.

Wrought iron is manufactured from pig iron by a process which removes most of the carbon and renders the metal fibrous in character, rather than crystalline.

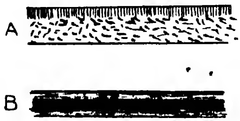


FIG. 11. Sections of A chilled steel; and B three-ply steel, as used in plough breasts

Wrought iron is tough, ductile, and will withstand shocks. It can be welded (whilst cast iron cannot by ordinary methods), but wrought iron cannot be cast. Wrought iron is obtained in bars of various shapes and sizes and is the material with which the blacksmith does most of his work.

Steel contains more carbon than wrought iron, but less than cast iron, and is purer than wrought iron. High carbon steels are of great hardness and tensile strength. They are hardened if heated to redness and quickly cooled. Mild steels contain less carbon, are ductile, and stand compression strains well.

Steels are known by various names according to their method of manufacture, each type being suitable for special purposes. Blister steel is of very good quality high carbon type. It is brittle and crystalline in character. From it, by reheating and rolling, is made shear steel, a more fibrous metal used for large knives, scythe blades, etc. Bessemer and open hearth steels are used for a wide range of purposes.

Steel castings give great strength and durability combined with lightness, and replace iron castings where the superior quality is required. They can be chilled like cast iron, a notable instance being the chilled steel plough mould-board. Steel castings are usually annealed (i.e. softened on the outside by reheating), and correspond to malleable cast iron.

Casehardening consists in raising the carbon content of the outer skin of steel by baking the article with a carbonizing material, such as charred leather, bone, prussiate of potash, etc. This produces a glass hard

surface, while the interior remains soft and fibrous. The same process can be applied to wrought iron.

Forging is the method by which wrought iron and mild steel is generally worked up into parts for machinery. It consists in shaping up the metal, usually at white heat, by the hammer (for heavy work the steam hammer is used). Forgings are of necessity plain in shape.

Welding is a process by which two separate pieces of wrought iron or steel may be joined together. It consists in heating the adjacent portions of the two pieces till they begin to run, and then hammering the two together. A properly welded joint is practically as strong as the solid bar. Highly specialized processes of oxyacetylene and electric arc welding are used for the repair of cracked castings.

Tempering is the hardening process applied to steel, in which the metal is raised to various degrees of heat and then cooled rapidly in water or oil.

Annealing is a softening process, the steel being heated to redness, and then allowed to cool slowly.

Anti-friction metals are used for lining the bearings in motors, etc., which are subject to hard running conditions, to reduce friction, and act as a safeguard against seizure of the bearing if insufficiently lubricated.

These metals are alloys of tin or lead, the former being the better. Two of the best known are Babbitt metal and white metal. The tin alloys may contain copper and antimony to harden them. Babbitt metal contains 84 per cent tin, 7 per cent copper, and 9 per cent antimony. Magnolia metal, a lead alloy, contains antimony 16 per cent, lead 83 per cent, and traces of iron, copper, and zinc. Some bearings in crushing mills, etc., are lined with gun-metal, a copper alloy containing tin and zinc.

The anti-friction metal is run into the bearing shell in its molten state and subsequently scraped to fit the journal. Brass bushings are also used in certain bearings on farm machinery.

With a few exceptions, notably the threshing machine,

there is but little wood used in the construction of farm implements. The chief characters of a few of the more important timbers are given.

Oak is tough, hard, and very durable, and is suitable for most purposes, although too costly for many. It is, generally speaking, the best wood we have. It cannot be used in situations where it has to come into close contact with iron, since it contains gallic acid, which causes the metal to rust.

Pitch pine is also hard, but of a different texture from oak. It contains large amounts of resin and lasts well, except in wet climates. It is mostly imported from America, and is largely used in the construction of threshing machines. A number of different grades of various pines and firs, known as deals, are used in joinery.

Beech is exceedingly hard, and is in general use for making the handles of tools, such as chisels.

Chestnut is grown in England largely for fencing and providing poles; while ash, as stated elsewhere, is very elastic, and one of its chief uses in farm machinery is in threshing machines, for making hangers

CHAPTER III

THE PLOUGH

THE mould-board plough still retains its position as the principal tillage implement, though attempts are being made to supplant it and other implements by the rotary tiller. Its original form was probably simply the branch of a tree, and in the course of thousands

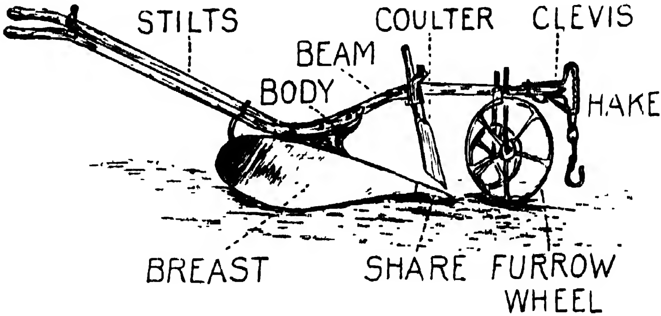


FIG. 12. A single furrow horse plough

of years the modern steel plough has been gradually evolved.

Dealing first with the single furrow horse plough, from which the tractor plough has been developed, we find that the implement comprises several essential parts, together with framework and means for control. Study of Fig. 12 will show the relative position of these parts. The beam is a long, straight member running from front to rear, and carrying all the other parts. Attached to the beam midway is the body, frame, standard, or frog, as it is variously termed. This carries the actual ploughing

parts. The coulter, mounted on the beam in front of the body, makes the vertical cut, separating the furrow-slice from the unploughed land. The share is carried on the foot of the body and fits flush up against the fore end of the breast. The share cuts the furrow slice horizontally, while the breast, mould-board, or turn-furrow performs the inversion of the slice.

On the left hand side of the body is placed the land-side, a long plate running from the share to the rear of the plough. In work, this bears up against the furrow wall and keeps the plough straight. Beneath the body is another

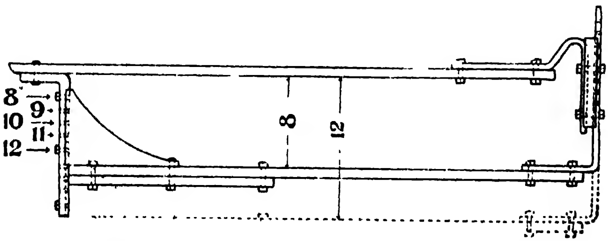


FIG. 13. Diagram showing the method of adjusting the distance between the beams of the Oliver No 8 tractor plough

plate upon which the plough slides, known as the slade, or sole. This may be in one piece with the landside.

Mounted on the front end of the beam are the land and furrow wheels, which help to carry the weight of the plough, and by means of which the adjustments for depth and width of work are partially made. At the extreme front of the beam is the clevis, consisting of the hake and quadrant in one form or another. By means of these alterations in the hitch may be made, which affect the working depth and width. In the case of swing ploughs, which have no wheels, the clevis constitutes the only means of adjustment for depth and width. At the rear end of the beam are fixed the stilts or handles, by means of which the ploughman guides and controls the plough.

In the gang plough, for tractor work, the beams are

strengthened and braced together, to form a framework carried on wheels—usually land and furrow wheels forward and a swivel wheel at the rear. The clevis is developed into

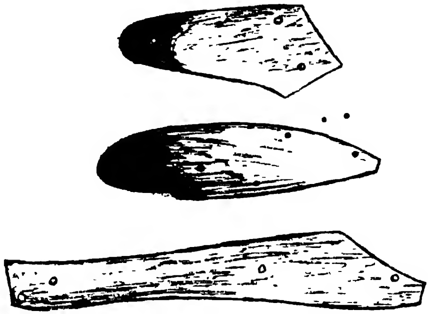


FIG. 14. The three main types of breast: digging (top), general purpose and Kent.

a specialized hitch, while an automatic self-lift gear is standard, by means of which the plough bottoms are raised clear of the ground when necessary. The designs adopted vary somewhat, but two principal types are

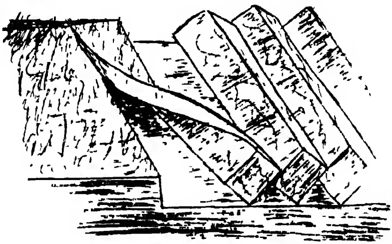


FIG. 15. Rectangular unbroken furrows

common and are in use on cultivators, etc., as well as on ploughs. The lifting of the implement out of the ground depends on partial rotation of the cranked axles on which the frame is carried.

The type of breast which is correct for given circum-

stances is a very vexed question, and much prejudice exists on the subject. There are a vast number of different types, ranging from the short digging breast to the long

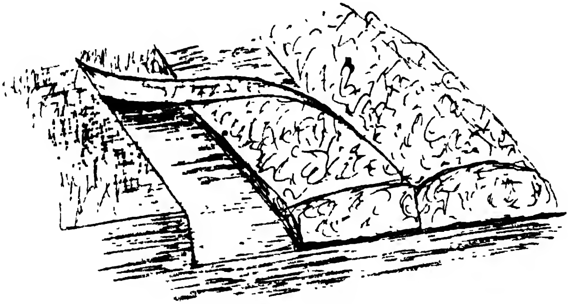


FIG. 16 Digging work

Kent pattern, many of these types being purely local. The long breast is narrow and somewhat convex in out-

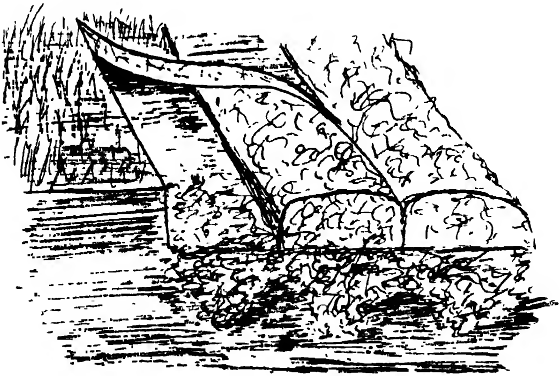


FIG. 17. The work of a digging plough fitted with a subsoiler

line. It has a very gradual turn, and can be set to invert the furrow completely. It presents little resistance to the soil and does not usually pulverize it. This type was designed for use on sticky clays.

At the other end of the scale is the short, concave digging breast with a sharp abrupt turn, which more or less completely pulverizes the soil and turns an inverted furrow. The general purpose breast, midway between the two, sometimes pulverizes the soil, and is usually set to lay the furrow at an angle of about 45°, cutting a rectangular slice. This is the plough most generally used, as it is suitable for most jobs on a wide range of soils.

The arguments in favour of the long type of breast are chiefly concerned with autumn ploughing, especially on heavy soils. It is considered necessary on this type of land to leave surface drainage channels under the furrows, and this is done by the long-breasted plough, which turns the furrows unbroken and packs them on edge. It is also said, with truth, that clay land which is too finely pulverized in autumn will cap badly after rain; in other words, that the surface will run together and set hard.

It is now possible to get digging ploughs that will work well in practically any soil, even stiff clays, if used when the ground is in the right condition for ploughing. The adoption of these ploughs, wherever possible, ensures a considerable saving of labour. As regards autumn ploughing on clay soils, it may be argued for the digger plough that the system of relying on surface drainage is wrong, and would be obviated by the use of the subsoiler to open up the lower strata of the soil and allow rain water to penetrate, instead of running off to waste. Further, in regard to winter capping, the digging plough seldom pulverizes clay so thoroughly in autumn as to cause much trouble on this score, providing good judgment is used. As a rule such ploughing will secure a good seeding tilth, with a quantity of lumps unbroken, which afford cover for the young plants and prevent serious cap formation.

The share cuts the furrow slice horizontally and enables the plough to penetrate the ground. For work under severe conditions, such as on hard ground, it is essential to have the share in good shape. Its form is usually

determined by the type of breast it is used with. The typical English share is narrow and pointed, this type being in use on most general purpose and long-breasted ploughs. These points give good penetration and are useful on stony land. They are from six to eight inches total width, and therefore do not cut the full width of the furrow slice, if the latter is of the standard width of about ten inches. The digging plough is usually fitted with a wide share, having a broad blade, which cuts the whole width of the furrow slice. This results in every thistle

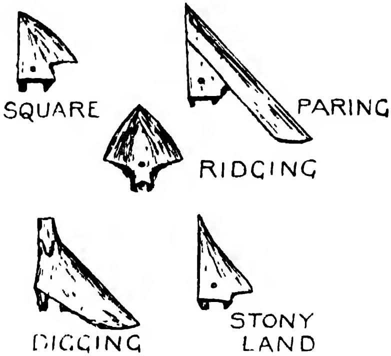


FIG. 18 Types of ploughshare

and other weed encountered being cut clean through, whereas with a narrow point tough rooted plants of this sort may escape being cut.

To give penetration the share must dip slightly at the point, and in order to retain this dip after wear has taken place many English shares are made self-sharpening. This is effected by their being chill cast, with the under side hard and the upper soft, so that the lower cutting edge always wears sharp. The share must also have a certain amount of set towards the land, in order to keep the plough well into its work.

There are several types of coulter in use, of which the

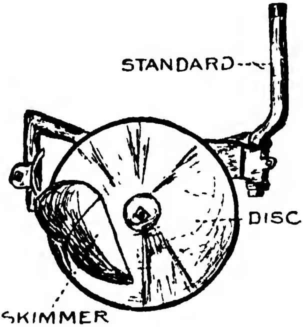
rolling disc is the most important. The best type of disc coulter is mounted in such a way that it is capable of swivelling, to clear any obstructions it may meet. It is

FIG. 19. A two-furrow tractor plough, the Oliver No. 8, specially designed for the Fordson

therefore slung in a fork, which is set on a cranked standard, attached to the beam. When the plough is in action the coulter follows in a direct line behind the point where the fork is attached to the standard. To set the coulter it is

necessary to turn the standard bodily to the left or to the right, in order to move the disc towards, or away from, the land. The vertical adjustment of the coulter is made by raising or lowering the standard.

The disc, being drawn through the ground, makes a vertical cut separating the furrow slice from the land. The setting of the coulter depends upon the nature of the work; but in ordinary circumstances the disc should be set so that a vertical line dropped from the hub falls a little behind the point of the share. The blade should be from three-eighth of an inch to three-quarters of an



A typical rolling coulter, fitted with skim

inch to the land side of the share. The lowest part of the disc should be about one and a half inches above the point of the share under average conditions, but if the ground is very hard it may have to be raised higher, in order to give the plough better penetration.

The rolling coulter possesses a number of advantages which render it the best type to use in nearly all circumstances. Its draft is light, it runs clean in foul land, and it enables a good furrow to be turned.

The knife coulter is commonly used on horse ploughs, but is not so generally satisfactory as the disc type. It consists simply of a plain cutting blade, mounted on a standard,

by means of which it is fixed to the beam. It is set in a similar position to the disc coulter, but with the blade sloping backwards. This type of coulter is simple, and its setting can be easily understood. It is cheap, and on most jobs it can turn out fairly good work. On the other hand, its draft is heavy; in foul land it is continually clogged with weeds; and on rough land stones frequently become jammed between the point of the share and the coulter. For this reason it is necessary to set the point of a knife coulter closer down on to the share than is the case with a disc coulter.

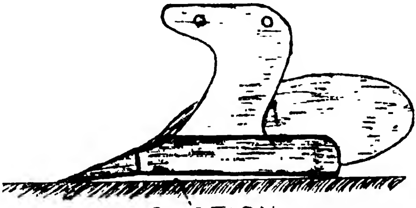
In all cases where there is any quantity of vegetation to turn under a skim coulter should be used. This is practically a miniature plough, fixed in such a position that it will pare off the top left hand corner of the furrow slice and roll it over, so that it falls into the bottom right hand corner of the furrow, to be completely buried by the furrow slice. For ordinary work, such as stubble ploughing, quite a small skimmer is sufficient, while for ploughing old grass it may be advisable to use one large enough to turn nearly a complete furrow. Where the skim coulter is combined with a disc coulter on the one standard the point of the skimmer should be set as close as possible to the face of the disc, without touching it. This prevents rubbish getting between the two.

On many digging ploughs there is no coulter proper. The front edge of the breast is developed into a sharp cutting edge (the shin), and a large type of skim coulter, known as a jointer, is used.

We have seen that in order to secure penetration in hard ground it is necessary for the share to set downwards at the point. It is also necessary that the whole of the under side of the plough be set correctly. If on a plough correctly set we lay a straight edge from the point of the heel to the point of the share, we shall find that the line of the sole and land side deviate upwards from the straight line, the deviation being known as the vertical suction. This can be measured with a rule, the greatest suction

occurring close to the front end of the land side, where the share joins the breast. The amount of vertical suction given varies, according to the penetration required, up to about three-quarters of an inch.

In addition to vertical suction there is a certain amount of horizontal suction, measured between heel and share as before, which keeps the plough in to its work, up against the unploughed land. The amount of horizontal suction is much less than the vertical suction. It should be clearly understood that the term suction, as used of a plough, does not imply that there is any negative air pressure under the plough.



SUCTION

FIG. 21

The wing of the share must bear on the bottom of the furrow to a greater or less extent according to soil conditions. To measure this, lay a straight-edge across the under side of the share from the point of the wing to the land side. The amount of bearing equals the distance the straight-edge touches the under side of the share. No bearing should be given for hard soils, but a wide bearing for soft ground. Half an inch is a medium amount for wide shares. Insufficient bearing is indicated in a single furrow plough by a tendency to dip on the mould-board side. Much less bearing is required on a gang plough, since the bottoms are kept in position by the frame and wheels.

While high-class firms make every effort to turn out ploughs and other implements which will wear well, yet some parts tend to wear out much more quickly than

others. In purchasing any implement it is necessary to observe whether the parts most subject to wear can be easily and cheaply replaced. In the case of the plough, the part which wears most quickly is the share. Now the ordinary cast share of the English type is fairly cheap to renew. On a digging plough, however, the share is large and expensive; consequently it is usually made in several sections, so that any of these can be replaced without scrapping the whole share. This particularly applies to the point, which naturally wears most rapidly.

The lower edge of the breast is another point exposed to wear, since it is usually in contact with the ground. In a number of ploughs a small wearing plate, which can be cheaply replaced, protects this part of the mould-board. The heel of the plough also wears fairly fast, and this should be renewable without having to replace the whole blade. Another important point to notice is whether the wheel boxes are detachable, to allow of replacement without scrapping the entire wheel. The same principle applies throughout the plough and indeed all other implements.

In connexion with the subject of wear, the attention paid to lubrication by the makers should be studied, since this will have an important bearing on the amount of wear which takes place. In a gang plough good grease cups should be provided for all wheel boxes, together with suitable means for excluding dirt. Grease lubrication is also necessary on rolling coulters and all other moving parts.

CHAPTER IV

OPERATION OF THE PLOUGH

IN use the plough operates by turning parallel furrows across the field, until the whole area is worked. A strip is left unploughed till the last, right round the field, known in most districts as the headland. Upon this the plough is turned at the end of each furrow.

When setting out a field with a tractor and gang plough the headland may be marked off first. To do this the plough should be set to turn a small furrow with the leading bottom. A piece of string equal to the required headland width is tied at one end to the front of the tractor. The other end is held by an assistant, who walks round the field close to the hedge or boundary, while the tractor is driven so as to keep the line just taut. When working single-handed, which takes much longer, the tractor driver will have to set up guiding sticks in order to mark out the headland.

The width required depends on the size of the tractor and plough, their ease of handling, and the shape of the field. With a light tractor, under favourable circumstances, the width necessary may be as little as four yards, but there is no object in making headlands so small as to make difficult turning. Where the furrows run diagonally on to the headland much greater width is required. The small furrow ploughed when setting out the headland should be turned out on to the headland, so that the ploughshares can be dropped on to the soft furrow when setting in. This saves many broken shares on some makes of plough.

To set out the ground for ploughing, the field is divided

into ridges, of a width which varies according to local requirements. Each ridge must be marked out by setting up sighting sticks in a truly straight line. The ridges should be set the longest way of the field, unless circumstances require otherwise, since a long furrow makes for economy in working. First find the position of the commencing ridge and set it out. Put up a pole at the headland at each end of the ridge and sight in one or more intermediate sticks. Then measure off equal distances parallel for the adjoining ridges. Any small irregularities should be ridged separately, the idea being to avoid running light more than necessary.

When starting on the ridge the furrow wheel of the plough has to run on the unploughed ground, and must be adjusted accordingly. Having set the plough in the ground the driver, after seeing the plough is working correctly, should drive to the other end of the ridge by his sighting marks, keeping his eye on these. He should not look back, or he will probably lose his line. The best way to commence the ridge is to plough the return furrow away from the first, then to plough the first two furrows together in the centre of the ridge. In this way no ground is left unploughed, as is the case when the first two furrows are ploughed inwards and left. Thereafter, furrows are ploughed on both sides of the ridge towards the centre, each ridge with its complement of furrows being known as a "land." It is obvious that each completed land will be separated from its neighbour by an open furrow. When the first ridge is half finished, the second should be started and carried to the same width as the first. The space between the two is then finished by throwing furrows on to the adjacent sides of the two ridges, until the ground left is all ploughed out. To avoid trouble in turning when the piece left in the centre is only a few furrows wide, it is best to finish by working two or three times right round one ridge.

When closing up like this, care must be taken to correct the width if the two ridges are not parallel, due to bad

setting out. This should be done before the unploughed strip is too narrow for the tractor and plough to turn on it. Any irregularity must be corrected by running short furrows on the wider end until the same width is reached right through. This trouble should not occur on level ground if care is taken in setting out, but it is sometimes unavoidable on side banks, where the plough tends to slip out of line. When the ridges are all finished the headland is ploughed by working continuously right round the field. This may be done towards the centre or towards the hedge, as desired.

The bulk of the ploughing should always be done in a straight line, since otherwise a proper furrow cannot be turned. Curved furrows, being of unequal width, leave trash uncovered and the ground open. Correct hitching is a most important point, as it is impossible to make good work with an incorrectly hitched plough. To understand the operation it is necessary to note the mechanical principles involved.

On the plough bottoms there is an imaginary point called the "centre of draft," at which the resistance to motion is concentrated. This is situated in each plough about twelve inches back from the point of the share, two to three inches from the land side, and two inches up from the bottom of the slade. In a gang plough the centre of draft is situated between the plough bottoms at a point depending on the number of furrows. Thus in a three-furrow plough the line of draft passes through the centre bottom, and in a two-furrow plough between the two.

An imaginary point on the rear axle of the tractor, situated centrally, is the centre of power of the tractor. The true line of draft is a straight line between these two points, and the outfit always tends to assume such a position that the mechanical connexions between tractor and plough fall in that line. This explains why incorrect hitching causes the plough to operate badly, and sometimes tractor "rearing" or side slipping. Fig. 23 shows

the correct hitching of a plough, with the clevis and draw-bar connexions falling in the true line of draft. Fig. 22 shows a plough incorrectly hitched. The line of draft would straighten out by the plough running on its point. In hard ground the back will rise; in soft ground the wheels will be forced down and the front of the plough will penetrate too deeply. In Fig. 24 the plough is again incorrectly hitched, and the front will be lifted and all ability to penetrate removed.

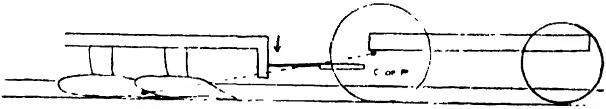


FIG. 22

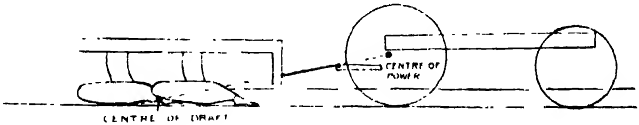


FIG. 23

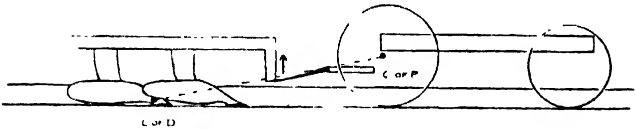


FIG. 24

Should the hitch be placed too high on the tractor, and the tractor is overloaded, the front wheels will rise, so that the centre of power is lowered into the line of draft, assuming that the hitch is placed behind the axle. If it is in front, extra weight is thrown on the front wheels and the driving wheels tend to slip.

Theoretically, the plough should be hitched so that its centre line of draft follows directly behind the centre line of power. In practice this is seldom possible. Except in the case of riding ploughs, which can be steered by the operator, tractor ploughs are usually hitched by means of

a rigid drawbar and brace rod. The plough pivots at the draw bar of the tractor, and the brace bar serves to push back on the front of the plough and correct any tendency to swerve. Lengthening the brace bar pushes the tail of the plough to land, and vice versa. Modern hitches now permit of this adjustment being made while the plough is in motion. On the original types the adjustment is made by means of a number of bolt holes, any combination of which can be selected. To make the plough take more land the hitch is shifted towards the land on the tractor

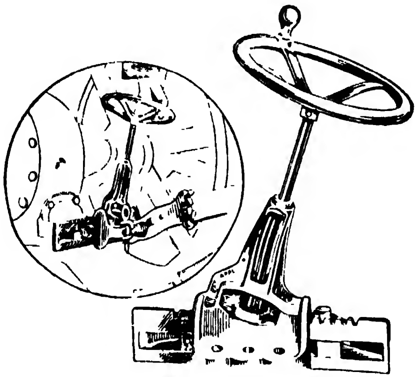


FIG. 25 The Oliver shifting hitch

draw bar, or if necessary away from the land side on the plough.

A number of sliding draw bar hitches now on the market enable the plough to be shifted sideways, while in motion, to overcome varying conditions of side draft.

The utmost pains should be taken to keep bright and free from rust the share, coulter, and breast, particularly the last named. Whenever a job is finished the plough should be freed from earth, and the mould-board and other parts wiped over with waste, lubricating oil, or grease. The waste from the crank case of the tractor should be used for this. If the plough is allowed to get rusty, scour-

Tractor	Plough	Number of Furrows	Condition of Soil *	Class of Land
Austin ..	Ransome RSLM-YL	3	Medium	Grass
Austin ..	Ransome RSLM-YL	3	Heavy	Clover Ley
Saunderson..	Ransome RSLM-YL	3	Light	Bean and Flax Stubble
—	Ransome RSLM-TCP (Digger)	2	Medium	Stubble
—	Hornsby No. 2 (Digger).	2	Medium	Stubble
Hart Parr 20	Massey-Harris	2	Light	Bean and Flax Stubble
Fiat ..	Massey-Harris	3	Medium	Clover Ley
Fordson ..	Oliver No. 282	2	Heavy	Grass

* Dr

TABLE I

Width Covered at each Cut	Average Depth in inches	Average Draw Bar Pull lbs	Average Resistance in lb per sq inch	Average Ploughing Speed (ft per min)	Average Draw Bar Horse Power	Acres Ploughed per hour	Fuel Consumed per acre in pints	Fuel per Draw Bar Horse Power hour
34	$5\frac{7}{8}$	1 720	8 60	170	8 85	0·49	24	1·92
27	$5\frac{1}{2}$	1 920	12 22	195	11 35	0 51	23 (petrol)	1·02 (petrol)
27	$7\frac{1}{2}$	1 030	5 08	246	7 81	0 67	20 60	1·78
23	8	1 070	5 8[illegible]	194	—	—	—	—
22	8	1 270	7 21	191	—	—	—	—
20	7	910	6 57	235	6 48	0 45	30 20	2·10
30	7	1 650	7 85	240	12 00	0 69	17 8	0·86
20	$5\frac{1}{2}$	1 230	11 16	280	10 45	0 58	23 5	1.30

…ry in all cases

ing trouble is sure to occur. All moving parts should be well lubricated when working.

When the soil slips easily over the mould-board, leaving nothing adhering to its surface, the plough is said to be scouring well. This condition is essential for good work and light draft; hence the necessity for keeping the breast in perfect order. Any irregularity due to a badly fitting bolt or share, etc., or pitting of the surface from rust or other cause, prevents good scouring. A plough will very often fail to scour in a soil which is not sufficiently cohesive to exert the ordinary pressure on the breast. Thus a fluffy soil will drive in front of the plough instead of slipping off the mould-board in the form of a furrow. Some clay soils which are very sticky and tenacious will not come away clean from the breast if worked when too wet. Heating the mould-board insures good scouring in such soils, and an American designer has utilized the exhaust gases of the tractor for this purpose.

In land where stones or stumps abound a break pin hitch should always be used. This is a hardwood pin inserted in a convenient point of the hitch, so that the pull of the tractor is taken through it. This peg is strong enough to transmit the power for normal ploughing, but shears and unhitches the plough in the event of striking any rigid obstacle. Thus damage to the plough is avoided. Plenty of spare pegs should be carried.

The effort required to operate a plough varies considerably with soil conditions, type of plough, size of furrow, speed, etc. The draft is measured in pounds at any given speed. With increased speed the draft has been shown to increase also. For every extra inch of depth the draft is usually increased by a higher ratio. The more the furrow is pulverized the greater is the power required. In most digging ploughs, however, this is offset by the reduced draft due to the chilled steel breast employed on these ploughs. Some of the figures obtained by the Watson dynamometer at the Shrewsbury tractor trials, 1921, are set out in Table 1.

The amount of ground that can be ploughed per hour depends of course on the tractor or team employed. With the average light tractor and a two-furrow plough in practice three to five acres per day of average ploughing should be accomplished.

In ploughing an acre the following distances have to be travelled on the average, so that the speed and steady running become the controlling factors:

TABLE 2

Width of Slice	Number of Furrows Ploughed		
	1	2	3
8 inches	$13\frac{3}{4}$ m.p.a.	$6\frac{5}{8}$ m.p.a	$4\frac{3}{8}$ m p.a.
9 ,,	$11\frac{3}{4}$,,	$5\frac{7}{8}$,,	$3\frac{7}{8}$,,
10 ,,	$10\frac{5}{8}$,,	$5\frac{5}{16}$,,	$3\frac{1}{2}$,,
12 ,,	$8\frac{7}{8}$,,	$4\frac{7}{16}$,,	3 ,,

Based on a length of furrow 220 yards and a width of ridges of 22 yards.

With short furrows, more idle running on the headlands occurs, with consequent loss of time.

CHAPTER V

SPECIAL PURPOSE PLOUGHS

THE DISC PLOUGH

THE disc plough, although it has been made in this country for export for some time, has never been much used here. A large concave steel disc replaces the share, coulter, and breast of the mould-board plough. This disc is set at an angle to the line of travel, and as it is drawn forward turns a furrow outwards. The furrow thus turned is rather different in shape from that turned by a mould-board, and is usually not more than seven or eight inches wide. The depth can be regulated as desired. It is necessary to set the draft so that the front of the plough penetrates to the required depth. The back is then weighted down to keep it in.

A good disc plough properly adjusted should penetrate into the hardest ground, while this type is useful on some peculiarly sticky soils in which a mould-board plough will not scour. It is probable that the disc plough would come into more general use in this country if trials were carried out with it so that its possibilities might become better known.

THE SKIM PLOUGH

Many general purpose ploughs can be fitted, if desired, with a wide paring share having a cutting width up to twenty inches. These are popular in some districts for paring stubbles about two inches below the surface and cutting off all weeds, etc.

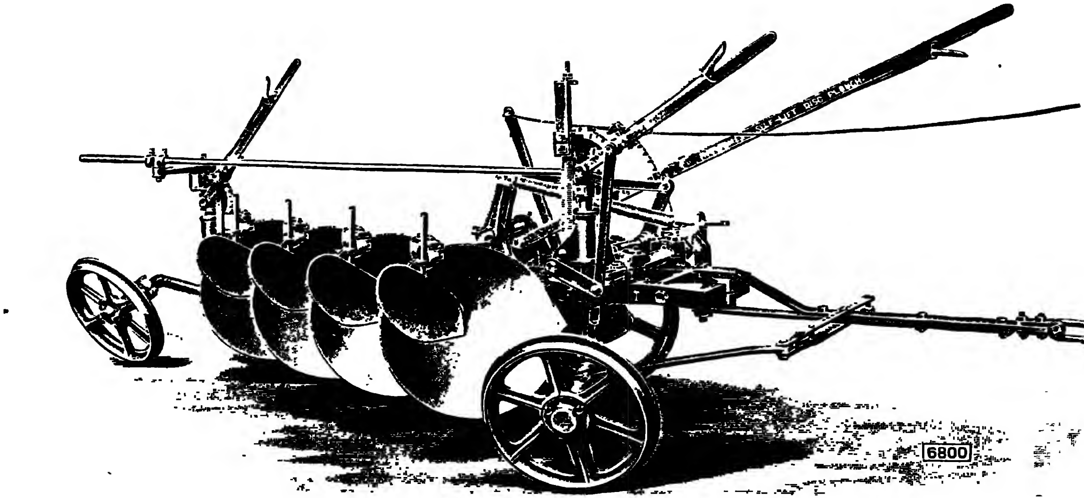


Fig. 26. A Ransome's self-lift tractor disc plough

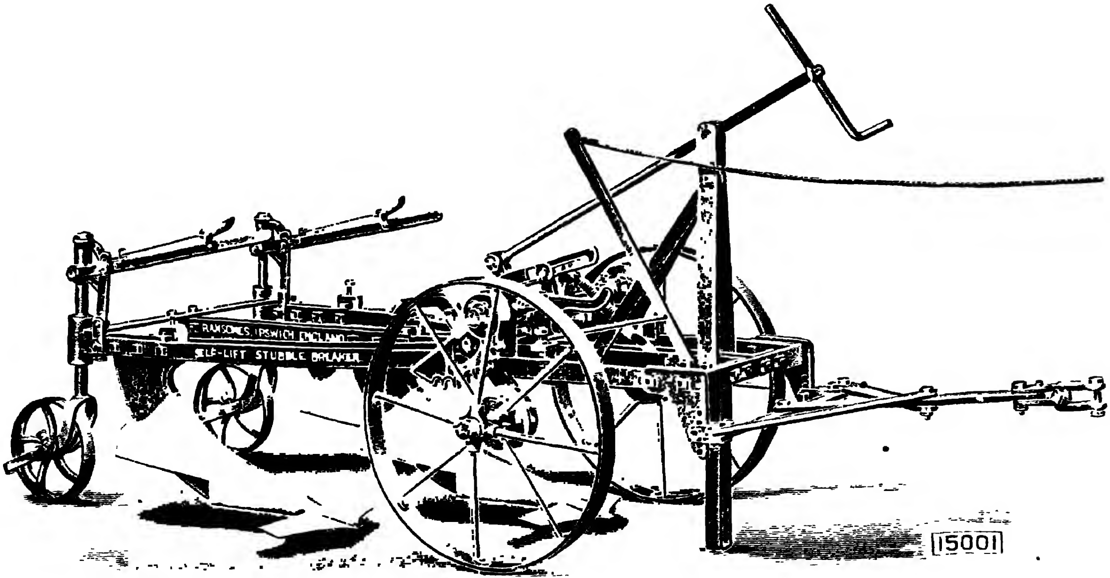


Fig. 27. A Ransome's self-lift tractor stubble breaker

This idea has been developed in tractor skim ploughs, which carry several wide skim shares, without the plough parts. These pare the stubble as described above, cutting off the weeds and forming a seed bed in which any ripe weed seeds can germinate. The young plants are then subsequently destroyed by further cultivation. These

FIG. 28. A typical balance plough for horse work

implements are fitted with a self-lift device, making a one-man outfit.

THE STUBBLE BREAKER

The broadshare is another type of wide-shared plough used for stubble breaking and similar jobs. It performs the same sort of work as the skim plough, but throws the surface into ridges and brings out any rubbish on the top. The broadshare is one of the oldest implements we have, but has been modernized and a form suitable for

tractor haulage placed on the market. Three bodies are carried on a gang plough type of frame, fitted with a self-

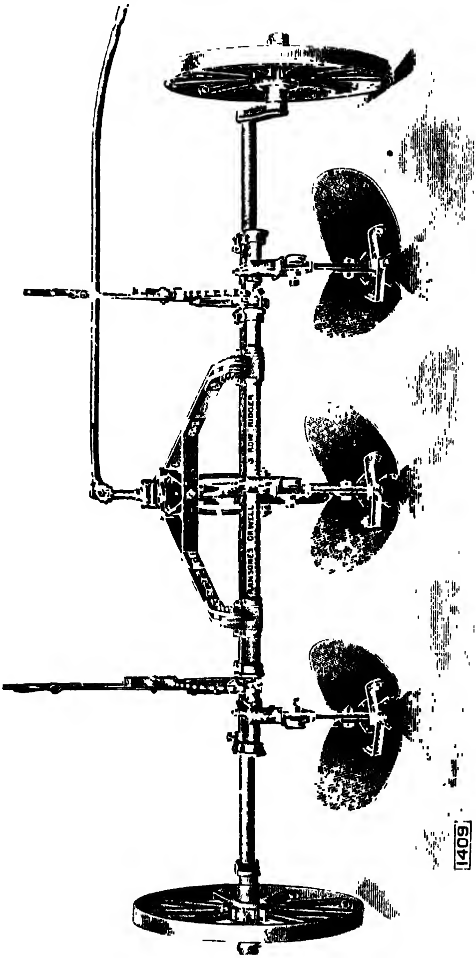


Fig. 29. A three-row ridging plough

lift device. Two bodies are placed abreast and a leading one between them. The tractor broadshare is also a useful

implement for spring work in breaking up ploughed ground that has laid over winter.

Tests of a skim plough and Ransome's stubble breaker were carried out at the Shrewsbury tractor trials, and a selection of the data obtained is set out in Table 3.

TABLE 3

Implement	Number of Shares	Width Covered at One Cut	Depth of Working	Speed (ft per min.)	Average Draw Bar Pull (lb)	Average Pull per sq. inch of Furrow Section
A B C Skim Plough ..	4	62 in	7	194	1460	3·36
Ransome's Stubble Breaker	3	54 in.	5	176	1770	6·56

ONE-WAY PLOUGHS

One-way ploughs of various types have been used for many years for horse and cable work, but this type has not yet been developed to the same extent for tractor use.

These ploughs can turn a furrow to the left as well as to the right, and are worked to and fro across the field instead of round ridges. Work is started at one side of the field and continued till the other side is reached, the right and left hand sides of the plough being used alternately. Many advantages are gained by this system, including no setting out, land left level (which makes for easier drilling, and saves wear and tear on the binder at harvest time), less compacting of the headlands, and less idle running.

For tractor work a two- or three-furrow balance plough can be used, but this entails the employment of an extra hand, while changing over at the end of each furrow is a tedious process. The balance plough is quite simple in construction. Five- and six-furrow balance ploughs are the standard type for use with cable tackle.

Single-furrow one-way ploughs include the reversible side by side riding type, the turnwrest, and the butterfly types.

FIG. 30. A Canadian type of reversible one-way ridging plough

Ploughing on the cable system, with one or two heavy steam or internal combustion engines, a very large acreage can be covered in a day. A five- or six-furrow anti-balance

plough is employed, and is usually hauled from end to end of the field by two engines alternately. The idle engine moves forward a short distance on its headland, while the other is working.

The system is falling out of favour in this country owing to the heavy weight of the ploughing engines, their high initial cost, and the inferior quality of the work. Probably the chief value of cable tackle is for bringing rough, uncultivated land under the plough, when levelling tools, cultivators, and harrows may be employed as well as the plough.

THE RIDGING PLOUGH

Ridging ploughs are double-breasted, without coulter, and with a narrow point instead of a share. They are used for throwing land up into baulks or ridges, as for potato growing Multiple furrow ridging ploughs for tractor use can now be obtained, and the majority of strong framed cultivators can be fitted with three baulking bodies, which replace the tines.

CHAPTER VI

DRAINAGE MACHINERY

THE SUBSOILER

FOR breaking up the soil below the usual limit of cultivation subsoiling ploughs or attachments are used. The ordinary subsoil plough has a beam and stilts similar to the single-furrow general purpose plough, but more strongly built. This carries a deep body, with a narrow point or share, the front of the body being fitted

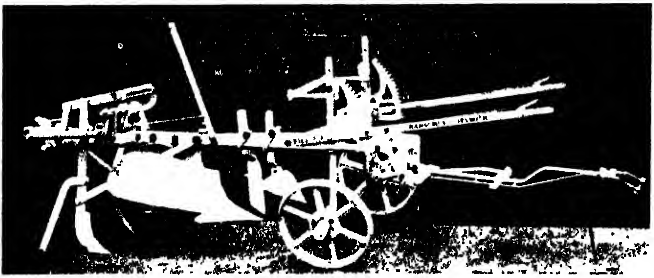


FIG. 31. Ransome's deep digging and subsoiling plough

with a sharp shin. A pair of wheels of equal size is fitted. This tool is designed to work in the bottom of a furrow previously turned by an ordinary mould-board plough. It breaks up the subsoil without bringing any of it up to the surface, and the next furrow is ploughed over the work done by the subsoiler.

Subsoiling attachments for use on general purpose ploughs follow the same general principles. The attachment takes the form of a stout tine, which is attached to

the frame of the plough either in front of or behind the breast, and works in the bottom of the furrow. For tractor work one of the best outfits is a special deep digging plough with a subsoil tine attachment in rear of the breast.

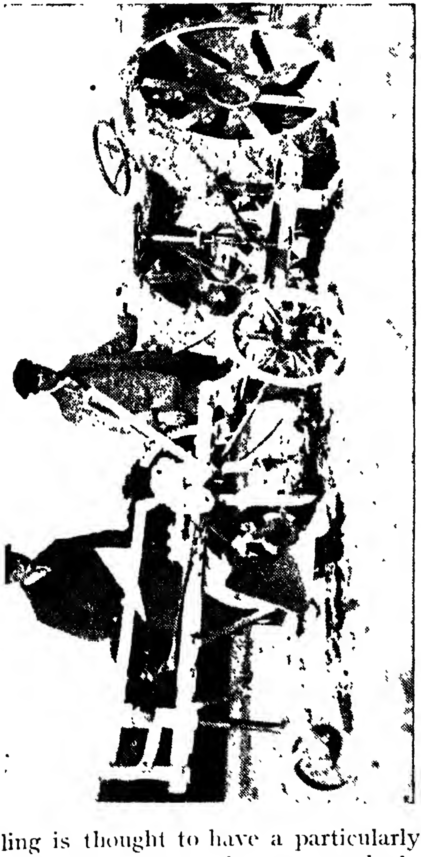


FIG. 2. Fordson tractor, fitted with a Celliers subsoiler, hauling a Sellars deep digging plough

Subsoiling is thought to have a particularly beneficial effect on heavy clay soils, as it opens up the lower strata to aeration and gradually increases the depth of fertile

TABLE 4

SOIL, MEDIUM LOAM 7–10 INS WITH CLAY SUBSOIL									SOIL DRY.
Plough and Subsoiling Attachment	Power	Average Dimensions of Work			Average Speed During Test	Average Traction Loads			Estimated Percentage of Effective Disruption of Pan below Ploughed Section
		Ploughing		Sub-soiling		Ploughing	Ploughing and Sub-soiling	Percentage Increase due to Subsoiling	
		Width	Depth	Depth					
		in.	in.	in.	m p h	lb.	lb.		
Ransome Deep Digger	British Wallis Tractor	10	7·5	5·5	2·21	816	1,391	70·5	88
Ransome Kent Breast	Weeks Dungey Tractor	10·5	7·25	5	1·47	825	1,133	37·3	76
Ruston and Hornsby Deep Digger	British Wallis Tractor	14	7·9	5	1·10	925	1,125	21·6	66
Ruston and Hornsby 2-furrow ..	British Wallis Tractor	10	7·23	5·83	1·87	704	1,160	65·1	85
Sellars Deep Digger and Celliers Subsoiler	Fordson Tractor ..	10	7·4	5	1·86	1,003	453*	—	67
International Plough, Darby Sub-soiler	International Junior Tractor	10	7·4	5·1	1·79	799	1,200	50·2	86
Ransome's Horse Plough.. ..	3 Horses	9·5	6·9	5	1·10	490	822	67·8	—

* Pull due to subsoiling alone

soil, in addition to improving the natural drainage. It is most important that precautions be taken to prevent any of the raw subsoil being brought to the surface. With a well-designed implement of this type there is no fear of this happening if the tool is worked properly. Tests of subsoiling devices by the Ministry of Agriculture at Tonbridge in October, 1922, resulted in some useful data being collected, portions of which are set out in Table 4.

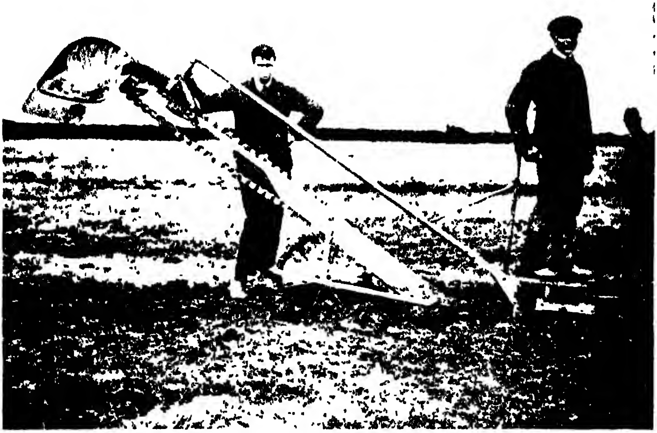


FIG. 33. At work with a Revolt drainage excavator

The Celliers subsoiler, of which particulars are included in the table, is one of a type which presents several advantages. It is designed as an attachment for the Fordson tractor, and is situated just in rear of the furrow drive wheel. It is thus easily controlled and can be used with any type of plough.

THE DRAINAGE EXCAVATOR

The cutting of trenches for laying drain pipes can be quickly and cheaply done by a mechanical drainage excavator. These machines, which were originally intro-

duced from Sweden, make excellent work in any deep soil free from large stones—in fact, on practically any soil which requires draining.

The machine is quite simple, and comprises a sharp-edged scoop or share of the required width, behind which runs a sloping elevator, which raises the soil cut out by the share. At the top of the elevator is a wide chute,

FIG. 31. Section of a mole drain cut in a heavy soil

which delivers the soil on to the ground at one side, clear of the trench. The depth of each cut is regulated by an adjustable foot, which is situated just in front of the share. As the share cuts a slice a few inches thick each time the draft is not great, and the necessary depth is attained by making a number of traverses of the field. With a light tractor hauling the implement a trench seven inches wide and three feet deep can be cut at the rate of about 150 to

180 yards per hour in stiff clay. The machine is also suitable for cutting trenches for water pipes, etc.

A wide type, cutting a 14-inch trench, is suitable for cleaning out and making surface drains.

THE MOLE PLOUGH

Where the expense of putting in tile drains is not justified, mole draining is often resorted to. The mole plough may be designed for tractor or for cable haulage, and consists simply of a frame and carriage, on which is mounted a massive knife coulter. At the bottom of this is carried the mole plug. This is a sharp-pointed cylinder of steel, two to three inches in diameter. As the tool is hauled through the soil the mole cuts a tubular passage, at whatever depth it is set. If the soil is of a sufficiently solid nature the mole drain should remain open for from fifteen to twenty years.

The drains are led either into ditches or into pipes. The depth depends on the nature of the soil and local conditions, but it is generally recognized that about eighteen inches is usually sufficient. While certain mole ploughs are self-entering, many require eye-holes to be dug for their entry, unless a ditch is situated convenient for the purpose.

CHAPTER VII

CULTIVATORS, HARROWS AND ROLLERS

CULTIVATORS

CULTIVATORS are an important class of tillage tool operating by the action of a number of tines, which break up the soil but perform no inversion.

The rigid tine type has a strong framework, built up of mild steel bars, the general arrangement of the frame being similar to that employed in tractor skim ploughs. On this frame is mounted a number of strong steel tines, arranged in two or three rows according to the make, and spaced equidistant from one another. Each tine is curved at the end so as to point down and forwards, to give penetration. A detachable point, of which several patterns can be obtained, is used to take the wear on the foot of the tine. On tractor cultivators a self-lift is fitted, which usually acts on both wheels. The latter are adjustable to allow the cultivator to be used at any required depth.

This type is of particular use where it is required to open up hard ground, the draft, however, being heavy, as is to be expected. There is not much pulverizing action, the ground being left in large clods. Thus this type is not suitable for directly producing a seed bed, but is valuable for use in conjunction with a disc harrow.

In circumstances where a pulverizing action is required, in addition to its use for merely breaking up the ground, a cultivator of the semi-rigid tine type has to be used. In this implement the design of the tines differs from the pattern described above. Instead of being straight for the greater part of their length, the tines are sickle-shaped

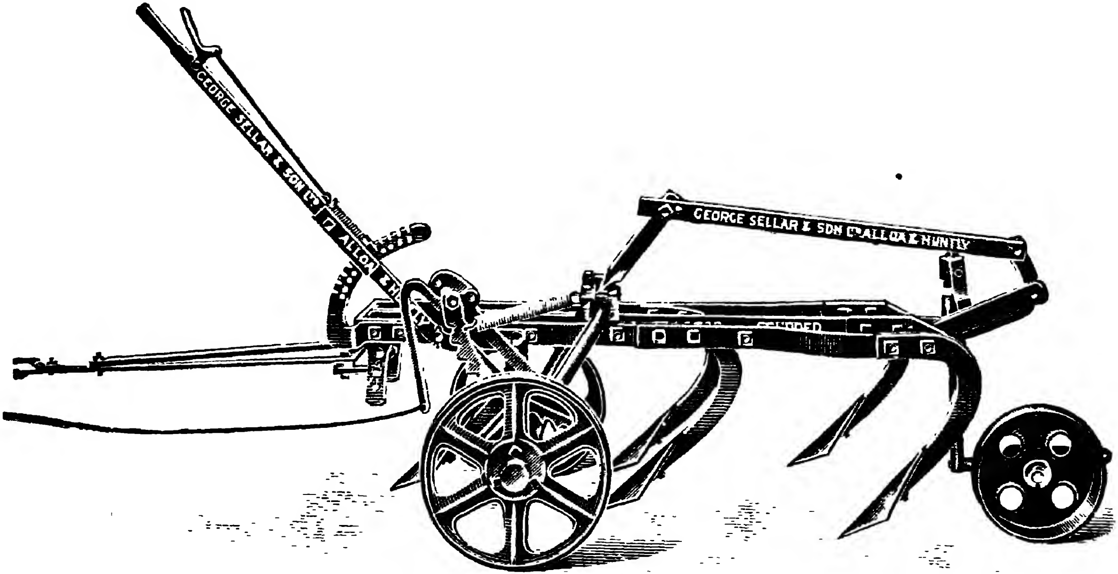


FIG. 35. A Sellars grubber for deep work with a tractor.

and are pivoted on to the frame. To hold the tines down to the work springs of various types are used. These allow the tines a short range of up and down motion, as

Fig 36. The Oliver self-lift cultivator

well as some side play. Thus when the implement is in motion the tines are continually vibrating, and thus tend to shatter the soil they come in contact with. This action is dependent to a great extent on the speed at which the

tool is operated. For this reason, amongst others, it is wise to employ a cultivator well within the capacity of the tractor or team, so that it can be pulled easily and a good speed maintained. The frames of these cultivators are more lightly built than those of the rigid type, since the strain imposed is not so great. As mentioned in the section on ploughs, the majority of cultivators of this type can be fitted with three ridging bodies for use in baulking land. For this work it is generally necessary to extend the axle width. On machines designed for this adaptation, provision is made for doing this quite easily.

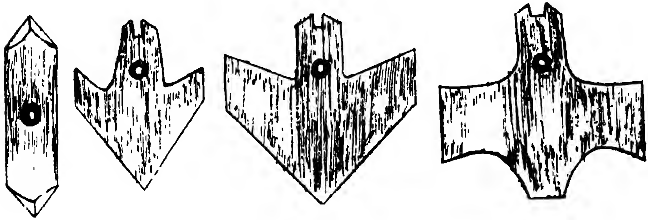


FIG. 37. Types of cultivator point. Left to right—narrow, medium, wide, and thistle cutting

Various patterns of detachable points are shown. When using the wide patterns, for cutting weeds in stubble cleaning, the tines should be set so that the points are flat in the ground, in the same position as a paring share. In this way the best work is done with the lightest draft.

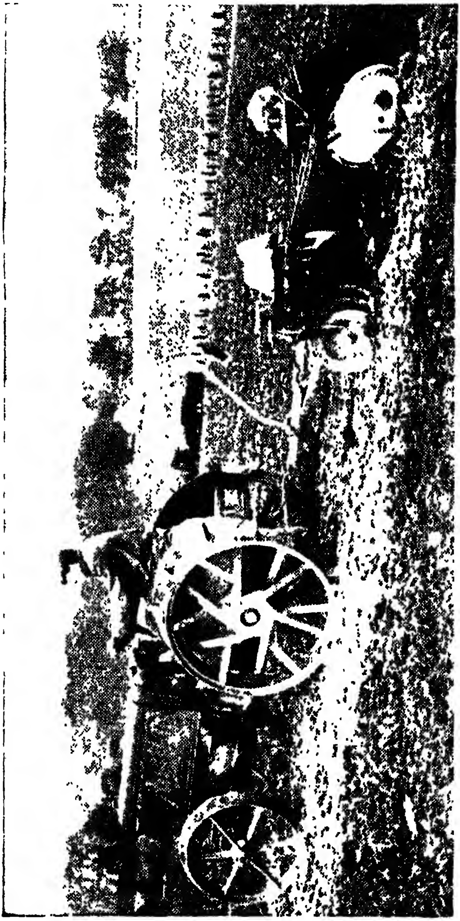
THE HORSE HOE

For cultivation in between rows of growing crops, such as potatoes and mangolds, small cultivators known as horse hoes are employed. These usually have rigid tines, fitted with blades of various patterns. The beams are frequently of the expanding type in order to fit the hoe for rows of different widths.

A particularly good type employs discs in place of the tines, after the fashion of a disc harrow.

THE DISC HARROW

One of the finest tillage tools ever built is the disc harrow, which consists essentially of two sets of steel discs



mounted at an angle to one another on a framework. The convex faces of the discs in each set are generally set

towards the centre; each disc is thus at an angle to the line of draft, and this angle can be altered by means of a device on the implement. As the discs are drawn through the soil they cut through any clods they encounter, while lifting, turning, and pulverizing the soil. The depth of working is regulated chiefly by the angle at which the discs are set: the less the angle between the discs and the line of draft the deeper is the work. Weight pans are also provided, which can be loaded as required to attain any depth of working. The greatest pulverization is obtained with the discs set at a wide angle.

For tractor work tandem disc harrows are used. These comprise two sets of harrows, one behind the other. The rear set has its discs set with the convex faces the reverse way to those in the leading set, so that the soil is turned two ways in the one operation, and the harrow is doubly efficient.

The discs in each set are mounted on a long gang bolt, usually of square section, on which are also threaded distance pieces to separate the discs. There are usually two bearings to each gang, and these are of various types. Owing to the fact that it is practically impossible to exclude dirt entirely from the bearings they are generally lined with a hardwood bush. This type of bearing wears well and is cheap and easy to replace when worn. In the leading set the thrust due to the action of the harrow occurs in an inward direction, and is taken by heavy plates on the two innermost discs. In the case of the rear set the thrust is outwards, and provision has to be made for this in the bearings; hence it is the practice in some cases to fit a ball thrust bearing on each rear gang.

Scrapers, to free the discs from soil when working in damp weather, are always fitted. These are put on in sets, one to each gang. They should be so designed that they can be easily thrown into or out of action. They should not be allowed to bear on the discs unless soil is adhering, since they cause unnecessary draft and wear.

Various patterns of disc are made, including the cutaway and spading types, but for all ordinary conditions the plain disc will be found most satisfactory. The discs should be of fairly large diameter—from 16 to 20 inches.

The disc harrows are exceedingly valuable for reducing intractable clods on heavy land, especially in the spring and summer. They reduce the amount of labour expended

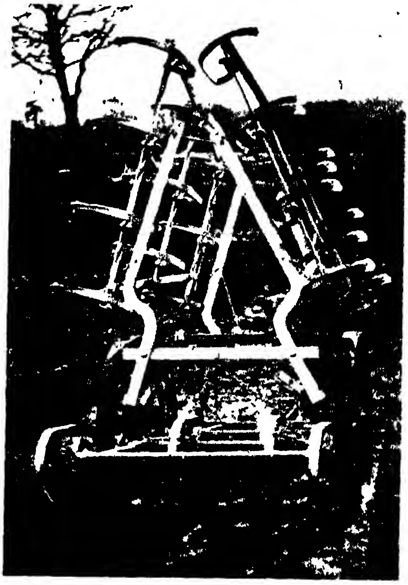


FIG. 39. Martin self lift tractor spring tine harrow, folded for transport

and materially lower the cost of producing a good tilth. In preparing light stubble or other ground for catch crops, etc., they will frequently produce quite sufficient tilth without the use of a plough.

It should be noted that it is not advisable to work a disc harrow on land very foul with couch or coltsfoot, as the

implement tends to cut the roots into small pieces, which serve to spread the pest.

TINED HARROWS

The spring tooth harrows more or less resemble the cultivators. They consist of a number of spring steel tines, bent on the flat into a curve and attached at the inner end to transverse bars. Thus the teeth are moderately rigid, but are capable of springing upwards, while their points project forward so as to enter the ground. By means of suitable levers the tines can be adjusted to penetrate to whatever depth is required.

These harrows are useful for breaking up furrows where the land is not too heavy. They lift and pulverize the soil,

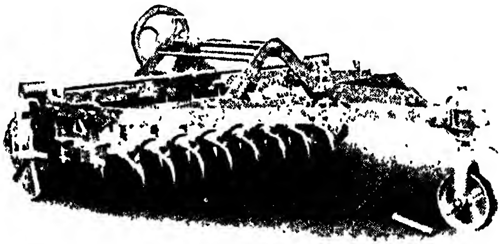


FIG. 40. The Stanford rotary harrow

the latter action being assisted by a slight side to side vibration, which generally occurs. They are also of value on stony land, where they will ride over any serious obstruction, and also in orchard work, since they do not damage any roots they may encounter. Spring tooth harrows are rather jerky in action, and the draft is therefore apt to be hard on horses. The fitting of wheels is an improvement in this connexion. In preparing a seed bed on most soils, the spring tooth harrow is of most use after the roughest part of the work has been done by the cultivator. To prevent the ground being left in ridges after the passage of this type of harrow, an iron pipe is

sometimes attached behind. These harrows should not be used after green or long manure has been turned under.

Spike tooth harrows are simple in construction, comprising a number of straight teeth held in a framework, in such a manner that when in action they stand in a perpendicular position. The commonest type is the zigzag pattern, this being the only form in which the teeth are spaced equally. The action of the spike tooth is purely one of pushing against the clods and stirring the ground at the surface. It is not therefore at all efficient for breaking down clods, although the heavy types of drag harrow are frequently used for such work. The proper function of the spike tooth type lies in the final refining of the surface soil, after the furrows have been broken up

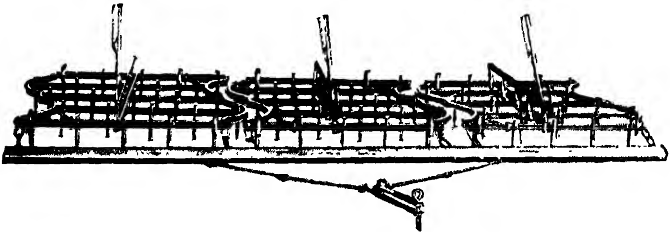


FIG. 41 The Oliver tilting spike tooth harrow

by the other implements. The other operations for which these harrows are specially suited are the covering in of seed after sowing, and the harrowing of corn in the spring to create a loose soil mulch on the surface.

In the tilting type of spike tooth harrow levers are provided, by means of which the teeth may be set at various angles, instead of being permanently upright. These are particularly useful, as they can be at once varied to suit any conditions or special jobs which may call for different penetration. Thus it can easily be seen that if the teeth are tilted point forward they will penetrate much deeper, and that the earth will be lifted while working. If the points are sloped backwards the work is much shallower and there is no tearing up action.

Smoothing harrows are constructed in large sizes for tractor use, and fitted with self-lift devices to enable them to be easily freed from rubbish.

CHAIN HARROWS

Flexible harrows made up of steel links are used chiefly for grass land work. A useful type is one in which two lengths of spike are provided, the harrow being reversible.

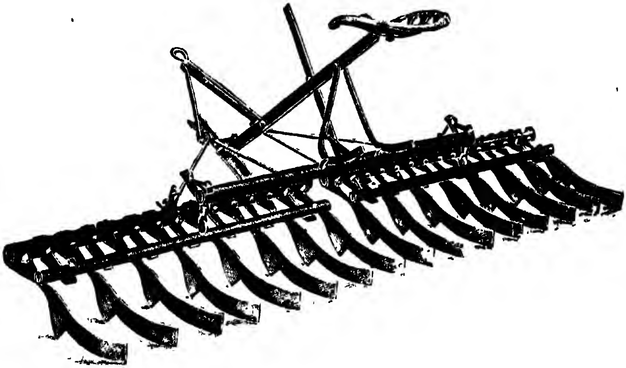


FIG. 42. The King-Acme curved knife tooth harrow

THE KNIFE TOOTH HARROW

The knife tooth or Acme harrow stands quite apart from the tine harrows, as its form and action on the soil are altogether different. These harrows are made up of a number of knife teeth, or coulters, tilted up at the front end, with a sharp cutting edge held parallel to the ground. In the curved knife tooth form these coulters have two curves in their length - one to the right and one to the left. This curve gives them somewhat the action of miniature ploughs, as the soil is turned over from side to side by the curved blades. As the harrow is drawn along, the coulters cut through any clods they meet, instead of pushing them aside, as in the case of a spike tooth.

TABLE 5

Implement	Type	No. of Tines or Discs	Maximum Width Worked	Depth	Speed	Average Draw Bar Pull
Nicholson Cultivator	Rigid tine	9	6 2	$4\frac{1}{2}$	183	790
Martin Cultivator	Semi-rigid	9	6 9	$5\frac{3}{4}$	260	1035
Ransome Dauntless Cultivator	Semi-rigid	9	6 3	6	180	1230
Roderick Lean Disc Harrow . .	Tandem 16″ disc	28	7 6	2	160	300 Discs at minimum angle
Roderick Lean Disc Harrow . .	Tandem 16″ disc	28	7 6	4	150	875 Discs at maximum angle of 20°
Martin Self Lift	Spring tine	29	12 0	$6\frac{1}{2}$	68	1440
Nicholson 4T	Zigzag	60	11 0	$4\frac{1}{2}$	165	1160

Tests on freshly ploughed light loam

A seat should be provided so that the driver's weight helps in the operations. The depth of working may vary from about one to four inches, and harrows of this type may be used for a wide range of jobs. The draft is not heavy, and a large amount of work can be got through in a day. When preparing a seed bed for roots, etc., the Acme harrow can be usefully employed after the land is broken up by the spring tooth harrow or the cultivator. It tends to compact the sub-surface soil, while bringing the top down to a fine tilth.

Extracts from the results of cultivator and harrow tests at Shrewsbury are set out in Table 5.

ROLLERS

Rollers of various types are in use for compacting the soil and are also commonly employed on many farms for breaking down hard clods, work for which they are hardly suitable.

All types are quite simple in construction, consisting for the most part, an axle supporting the upper frame, to which the shafts are attached, and carrying the roll cylinder. The design of the cylinder varies according to the work for which the tool is intended. Plain cylinders built in two or three sections are used for compacting seed beds before sowing and on grass land. In the Cambridge roll, used for rolling corn in the spring, the cylinder is built up of a number of narrow sections, each of which is fluted. Clod crushing rollers are made with the sections deeply toothed, the idea being to crack up the clods. These tools are not nearly so efficient for this work as the disc harrow, since in loose soil they often only push the lumps into the ground instead of breaking them. Many stone rollers are in use in some districts, and they are satisfactory for most purposes; but where the roll is used on grass or corn the cylinder should be made in one or more sections, to avoid tearing out the plants when turning, which happens when a single wide section is used.

For tractor use the expanding type of roll is the best.

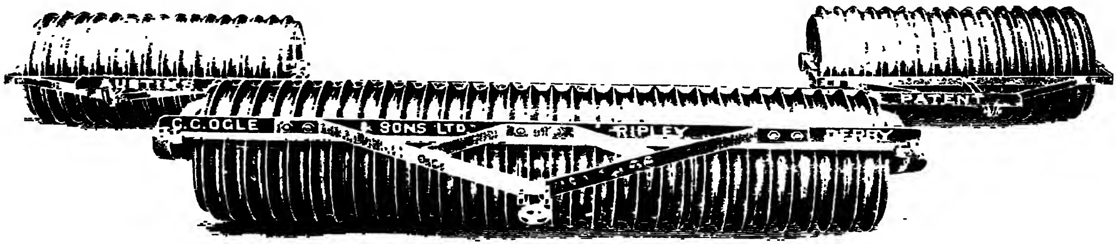


FIG. 43. An expanding Cambridge roller for tractor work

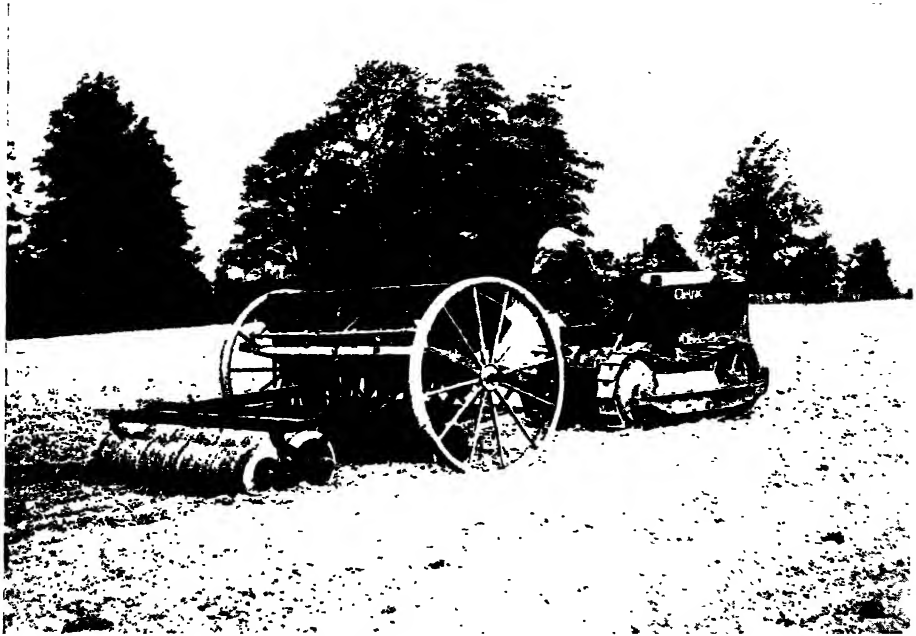


FIG. 44. An Oliver roll pack in use behind the drill hauled by a Cletrac tractor

These employ three separate axles and frames, hitched together. In the field the three work in line, but for travelling through gates and along roads the two outer sections close up behind the middle one.

THE ROLL-PACK

The construction of the roll-pack is very simple, and it is really a development of the ring roller. Carried on long axle shafts are two sets of crushing and packing rings placed tandem, the diameter of the rings in the leading set being about the same as that of a Cambridge roll. Those in the rear set are of smaller diameter than the leading rings, and by this construction lightness of draft is combined with great crushing power. The rings forming each set are built specially heavy, and their outline in section is more developed than in an English ring roller, the central rib of each being deeper and more sharply cut. This naturally gives better pulverization, approaching more nearly to the cutting action of the disc harrow. The flange also penetrates more deeply.

The ribs or flanges of the second set are arranged to fall in line between those of the first set, so that any clods missed by them are cut by the second set. The effect also of the curved flanges pressing into the ground is to firm the soil just below the surface. The total result is that the implement, if judiciously used, should leave the ground with the surface fairly loose and well pulverized, while the sub-surface is firmed, thus providing a satisfactory seed bed on which drilling can be carried out. The width covered at each stroke is about seven feet, while the weight is in the neighbourhood of half a ton. It is thus a suitable and handy implement for use with a light tractor.

CHAPTER VIII

ROTARY TILLAGE

MOST of the outfits at present made consist, with certain variations, of an internal combustion engine with suitable reduction and driving gears, controls, etc., mounted on a chassis, carrying at the rear a cultivating "miller." This consists essentially of a

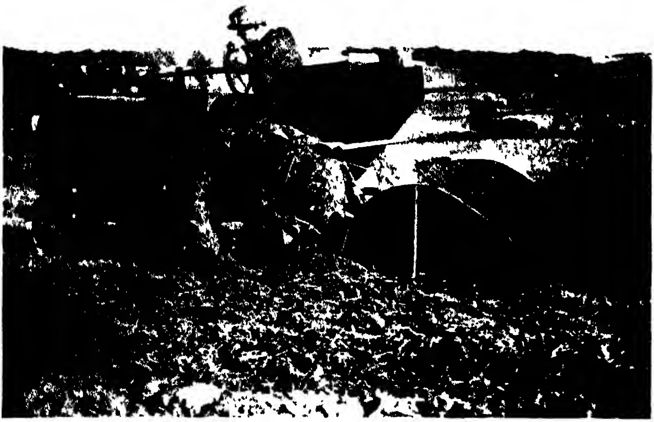


FIG. 15. Simar rotary tiller at the Scottish tractor trials, 1922

shaft mounted parallel to the axles of the machine and driven through some suitable transmission by the engine. On this shaft is mounted a number of curved hooks or tines which perform the cultivation. Thus, as the shaft rotates under engine power the tines successively enter

the ground, each tearing up a small portion of the soil and throwing it backwards behind the machine with some considerable force. The action of each tine is roughly imitated when a clod of earth is hit violently with the end of a stick and flies into fragments. Bearing this in mind, we may proceed to consider the nature of the work done by the miller.

The action of this type of implement differs from that of an ordinary cultivator or harrow in that successive portions of ground are treated in the opposite direction to the travel of the machine. The cultivator, on the other hand, works continuously forward. As a result the working of the miller helps to drive the machine forward, whereas when a tractor is hauling a cultivator the whole work devolves on the driving wheels. A further advantage results from the backward working of the tines in that the ground does not tend to drive up in front of the implement as in the case of a cultivator. Again, while the cultivator lifts the earth to a certain extent, and allows it to fall back, the miller of a rotary machine throws a considerable proportion of the soil several inches above the level of the ground The earth then falls back and forms a very loose mass to the depth of working, allowing free aeration for as long as the soil remains open. This depends on the nature of the soil and the weather which succeeds the working. If the soil contains much clay, and rain follows, it will soon set into a cap on top and aeration will cease. Thus, although the rotary tiller has somewhat the same effect as a cultivator, it is seen that one working with the rotary implement leaves the ground more highly pulverized than one stroke of the cultivator.

We must now compare the work of the rotary tiller with that of the plough, and this comparison is really the most important since the advocates of the newer system claim to be able to displace the plough.

The extent of the difference between the work performed by the two implements varies greatly according to the type of plough we compare with, but certain fundamental differences apply in any case.

The plough performs its work essentially by cutting and wedging the soil up and over, inversion taking place to a varying extent. Any pulverization occurring is due to the furrow slice shearing within itself, owing to the two sides of the furrow travelling different distances while turning over. In the case of the digging plough the soil is left in a more or less finely pulverized state to the bottom of the furrow, though seldom so finely pulverized as by the rotary implement, or so flat on the surface. The ground after ploughing, however, will be more compacted. Where a plough is used which does not pulverize the soil the result is very different from the work of the rotary tiller, the furrow slices being firm and solid, with passages along the furrow bottom for drainage. With a plough properly equipped and set all the trash is buried, and dung, green manure, etc , can be turned under. As a result of the nature of a plough the bottom of the furrow is generally left perfectly smooth and to a certain extent compacted by the passage of the sole.

The rotary cultivator differs materially on many of these points as well as other details Instead of the ground being cut into furrows it is simply torn up in small particles, and the amount of inversion taking place is negligible. There are never, of course, any under-surface channels left for drainage, and as there is little inversion taking place, any stubble or other trash is simply left lying on the surface. The limit of cultivation is probably not so sharply marked off from the lower soil by the cultivating tines as by the share of the plough, and very little compression at that point should take place.

The operation of these machines on foul land is somewhat difficult, as all weeds having fairly long roots or stems tend to bind round the miller shaft and cause some trouble. They deal fairly satisfactorily, however, with stony ground, the spring tines yielding on striking any large stone. The rotary tillers can also be operated successfully on hard-baked clays.

The sphere of usefulness of these machines is at present

a somewhat debatable point, and, although they possess a number of obviously good points, there are several conditions under which they are unsuitable. In this country, at any rate, there are very few situations in which they could be used for autumn tillage owing to the soil being left in such an excessive state of fineness. Again, although it is claimed that an ideal seed bed is formed in one operation, it must be remembered that the soil is left very loose to the full depth of working, and unless subsequently compacted below the surface before sowing, the young seedlings would never get satisfactorily established, owing to lack of moisture and absence of root hold. For producing a fine seed bed, in most cases, a really good digging plough will be found quite as efficient as a rotary cultivator.

As far as the production of a tilth for potato planting is concerned, however, this type of machine is eminently satisfactory, and leaves the ground in an ideal condition for the crop.

For surface cultivation in fruit plantations, hop gardens, etc., small models of rotary cultivators are well adapted, since the object in view is usually merely the production of a surface mulch, and the destruction of such annual weeds as spring up from time to time, when they are only partially developed.

CHAPTER IX

SEEDING MACHINERY

THE DISC DRILL

THE first drill for sowing seeds was invented by Jethro Tull early in the eighteenth century, but the value of his system of seeding was not recognized till many years later.

The drilling of crops ensures even seeding and allows of subsequent inter-cultivation. Economy in seed over the broadcasting method is also secured, and it is probable that further developments in this connexion will take place. The up-to-date types of drill are very efficient, providing for regular discharge of the seed, and easy control for various rates of seeding and depths of working.

The hopper, feed mechanism, and furrow openers of the disc drill are all built up upon, and are carried by, the frame of the machine, and to this feature attention should be paid when purchasing. It is essential that the frame should be extremely rigid and free from any tendency to sag under the weight of the hopper, or give as a result of draft strains. To secure these features without incurring excessive weight, the frame is generally built of good quality angle steel, pressed into the correct shape. This should be suitably braced at the corners and elsewhere to secure the required rigidity. This is especially important in drills of considerable width. At each side of the frame is placed a bracket carrying the axle bearing. Mounted on the rear part of the frame is the wooden hopper from which the seed is delivered by the feed mechanism to the furrow openers.

The feed mechanism typically adopted in the disc drill is some form of force feed. Along the bottom of the

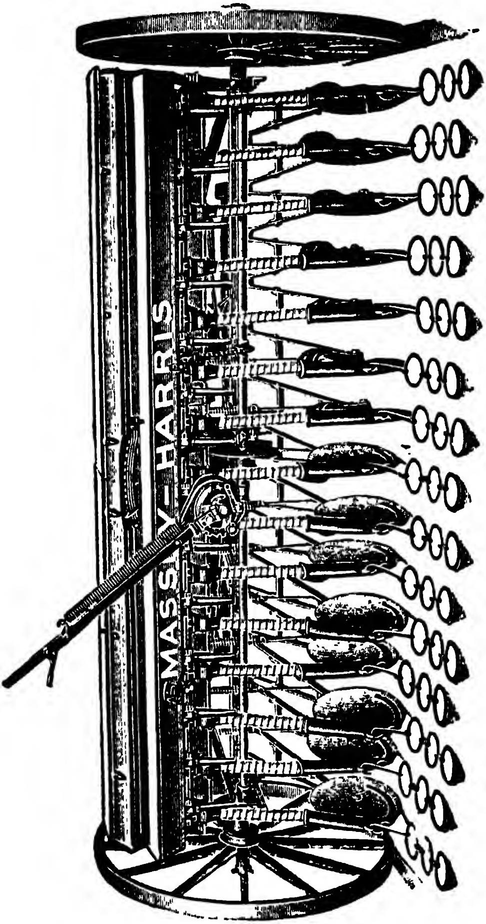


FIG. 46. A typical disc drill

hopper are placed the openings to the feed runs. In each of these runs is placed a feed shell, belonging usually to

one of two types. In one type the shell is a metal disc having each face dished and grooved. This is placed in the feed run, with its edges toward the front and rear. It thus divides the feed run into two portions. Each feed shell is mounted on a spindle, usually square in section, so that all the shells are driven at the same speed when the spindle is rotated. A few grains of the seed lying in the hopper in contact with the feed shell are therefore caught by each groove of the shell and carried round and led down into the seed tube running to the furrow opener, a constant stream being thus fed to the ground. The grooves on the two sides of the feed shell are of different sizes, in order to deal successfully with both large and small seeds, one side only being in operation at any time; the other side is blocked by a small plate provided for the purpose.

We have seen how each feed shell is driven by the spindle on which they are all mounted, and we must now consider the means by which this spindle is driven. Each of the main wheels of the drill is mounted loosely on the end of the solid live axle, and carries in its hub a ratchet and pawl gear, by means of which the axle is driven round when the wheels move forward. The wheels are thus independent, allowing one to overrun the other when necessary (for turning), and also permitting the drill to be moved backwards without rotating the axle.

About the centre of the axle is placed a face gear, so mounted that it turns with the axle, but can be slid along it for a short distance at will. This consists of a cast plate carrying a number of concentric rows of teeth. Each of these rows is capable of meshing with, and driving, a small bevel gear mounted on a vertical shaft. The shaft carrying the bevel wheel is usually square in section, and passes through a square hole in the pinion; consequently the bevel pinion can be slid along the shaft when required. By this means it can be made to mesh with any row of teeth on the face gear. At the top end of the shaft thus driven is a second small bevel wheel, meshing with another

mounted on the feed shell spindle. It is in this manner that the feed shells are driven from the axle.

The speed of rotation of the feed shells relative to that of the axle, and consequently the rate of sowing, is con-

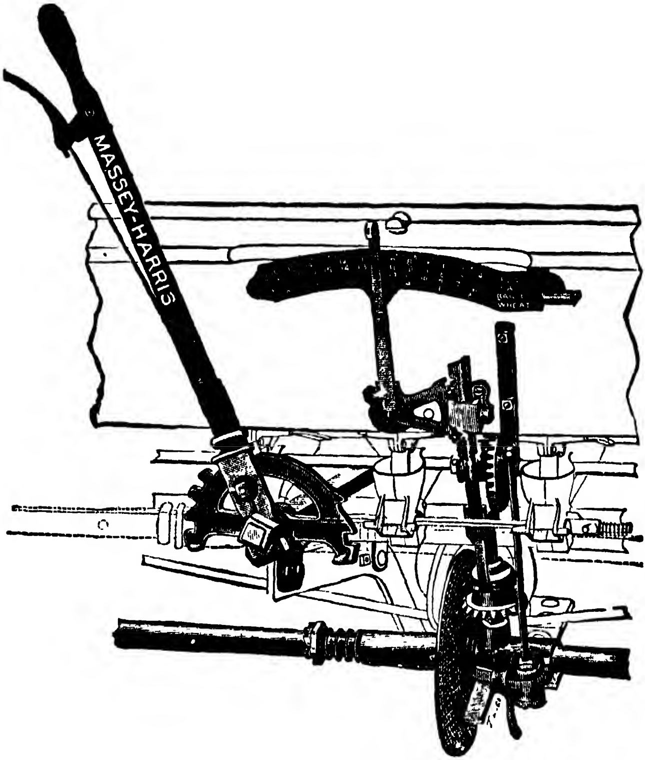


Fig. 47. Driving mechanism on a disc drill, showing the face gear and operating levers

trolled by means of a small lever mounted in a convenient position on an indicator plate. This lever is connected to the movable pinion which engages the face gear. By means of the lever the bevel pinion is made to engage with whichever row of teeth on the face gear corresponds to a

given rate of sowing. The outside row gives the fastest speed and highest rate of seeding and the inside row the lowest. To throw the seeding mechanism out of gear the face gear is moved along the axle so as to disengage the bevel pinion. In most makes this is effected automatically by the lever which raises and lowers the furrow openers. Thus when the discs are lifted out of the ground the feed is simultaneously cut off.

In the second type of force feed the shell consists of a small fluted barrel lying lengthwise in each seed run. Each of these barrels is mounted on a long square spindle in the same manner as the first type. Alongside each fluted barrel is a plain round shell of the same size as the feed barrel. This is mounted on the long spindle, but does not rotate with it. By means of the regulating control each barrel can be slid partially or wholly out of the seed run, the dummy shell taking its place. By this means more or less of the fluted barrel is exposed to the seed. Consequently greater or less amounts of seed can be sown without altering the speed at which the feed shells are driven, and the face gear is not employed in the drive. Instead, a suitable single geared drive embodying a clutch is used.

Whichever type of feed is adopted, the regulating lever moves on an indicator plate, marked usually in pecks per acre. These positions should give accurate settings when the machine is new, but when wear develops, and in inferior machines, the indicator may be inaccurate. In all cases it is advisable to check the acreage covered and the quantity of seed used. In most makes an acreage register is to be found, driven from the axle by suitable gearing, usually embodying a worm. This records the average covered. Its accuracy should be checked, if required, by actual measurement.

After being delivered by the force feed mechanism the seed is led down by seed tubes of various types to the furrow opener. Disc drills are divided into two important types, according to whether the furrow opener consists of

a single or a double disc. In the latter type of drill each furrow opener consists of two plain steel discs, mounted at a slight angle to one another. Of these one is usually set a little in advance of the other. The seed is led down to a boot placed between the discs and thence falls into the furrow.

Each pair of discs is mounted on bearings attached to the end of a small draw bar running forward to the front of the frame, and each furrow opener has its own independent draw bar. The front end of each draw bar is fastened in position on the frame by a set collar or similar device, and extending upwards, from a convenient position on each, is a rod and spring by means of which the furrow openers are brought in to or out of work and the pressure on them controlled. These rods are all connected up to a turning bar on the frame, which is controlled by the lifting lever. Each furrow opener has its own pressure device, consisting almost universally of a coil spring placed on the pressure rod. The force of this spring is usually adjustable by means of pins passing through holes in the pressure rod and over the top of the spring. Each can then be given greater or less compression. Since each furrow opener has its own draw bar and pressure spring, the drill can adjust itself to irregularities in the ground, each furrow opener working to the required depth almost irrespective of the ground surface. The furrow openers on standard drills are usually set five, six, or seven inches apart, but it is possible to alter the setting by moving the draw bars along the frame, loosening the set collars to do this. If the distance between the coulters is required to be much greater than standard, alternate feed runs can be blocked by means of small plates provided for the purpose.

In the single disc type the general arrangement of the furrow openers is practically the same as for the double discs, but each consists of a single disc, which is concave or dished instead of being plain. Each disc is set at a slight angle to the line of advance of the drill. In most

types an ordinary shoe is placed at the convex side of the disc, behind the bearing, and through this the seed is fed and deposited at the bottom of the furrow.

The single disc has several advantages over the double disc type which are sufficient to recommend it in preference to the latter. The single disc has much better penetration than the double, which is of course specially important where the tilth is not of the best, as may happen in an awkward season. It also has less tendency to clog, and cuts through any trash it encounters better than the double disc.

The disc drill has an important advantage over other types in that it performs cultivation while depositing the seed, and the effect of this is much more noticeable in the case of the single disc type, which tends to throw the surface into slight ridges. These, of course, are subsequently harrowed down again. The single disc has only one bearing for each furrow opener instead of two, which means less wear, while the reduction in the number of parts is also an advantage. On the side of the double disc type it may be noted that the seed is better distributed, each coulter opening a furrow slightly ridged in the centre, so that the seed really falls into two lines in each furrow.

With either type of furrow opener an important point is the bearing of the disc and the means provided for its lubrication. The usual metal is chilled iron, and lubrication is usually by means of screw down grease cups. This is satisfactory if dirt is properly excluded and a large bearing surface provided. In view of the success they have achieved in disc harrows, it appears that hardwood bearings might well be employed on disc drills.

On both types scrapers are provided to keep the discs clean when working on sticky ground. These should be adjusted as close as possible without actually touching the discs, when they are required, but when the ground is dry and no mud adheres, it is better to move the scrapers well away from the discs.

Accessories to the furrow openers, frequently furnished with disc drills, are covering chains. These consist of several large links and hook on to the back of the boot. They follow each furrow opener and cover in a considerable amount of the seed deposited. They cannot be relied on to replace harrowing after drilling, but at all events they are a great help and may even save one harrowing.

For tractor haulage a short stub pole may be used, while it is possible to have the drill fitted with a front steerage wheel, controlled by a lever extending back over the hopper. Markers can also be fitted at each side and very straight drilling can then be done.

When drilling in damp weather with a tractor, it may be advisable to fit up cultivator tines on the front of the drill to take out the wheel marks of the tractor. This can be easily done if a suitable bracket is designed and made to carry one tine in the line of each wheel track. In some cases it may be convenient to fit the tines on the tractor, but this is not always possible.

The draft of the disc drill is considerably lighter than that of the shoe or hoe types, especially in the case of the single disc. There are no English figures available on the subject, but a trial at the Iowa (U.S.A.) Experimental Station gave the following results :

	Discs	Width	Total Draft	Per foot
		feet	lb.	lb.
Double Disc Drill	10	6·7	450	67·1
Single Disc Drill	10	6·7	460	68·6

On average land a ten-disc drill should be well within the power of two horses, but where possible the wider width should be used with a tractor or three-horse teams. The acreage per day should come out at about one acre for every foot width of the drill under average conditions.

SPECIAL DRILLS

For broadcasting small seeds such as grasses and clovers for leys a hand-propelled seed barrow, covering a width of twelve to sixteen feet, is generally used. Delivery is commonly by means of a rotating brush, which sweeps the seed out through variable openings.

Small drills are also specialized for the sowing of roots on the ridge and on the flat. They are of simple construction and need no special description here.

CHAPTER X

ARTIFICIAL MANURE DISTRIBUTORS

THE commonest type of artificial manure distributor employs a long hopper similar to that of the corn drill for the carriage of the manure. Various makes differ in the method of delivering the artificials from the hopper, and the success of the machine chiefly depends on this point.

A large number of machines are fitted with an endless chain, carrying delivery fingers. This chain passes along the bottom of the hopper, when the machine is in action,

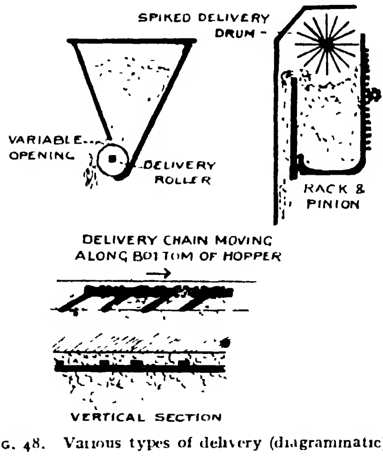


FIG. 48. Various types of delivery (diagrammatic)

and the fingers draw out the manure and deliver it through a slit in the back of the hopper. By varying the width

of the slit, and by driving the chain at a higher or a lower speed relative to the travel of the wheels, the rate of sowing may be altered.

To keep the manure free in the hopper some form of agitator, usually a reciprocating plate in the back of the hopper, is necessary. The plate is actuated by an eccentric geared to one of the wheels. To keep the chain from clogging up with manure various cleaning devices are employed, including brushes and scrapers.

Owing to the action of the chain, moving in the one direction, the manure tends to shift to one end of the machine, and it is necessary to allow for this when filling up, as otherwise at the end of the sowing the machine will be delivering from only one end of the hopper. In some cases check plates are fitted to overcome this difficulty. It is further advisable to fill the space below the chain with sand or ashes. If it becomes filled with manure it will soon become choked up with a sticky paste.

A number of machines employ some type of delivery roller instead of the chain. In some cases this barrel forms the bottom of the hopper. It is driven round by gearing from the main wheels, and carries out the manure. By varying the speed of the roller more or less of the manure can be delivered.

In other cases the delivery drum is placed outside the hopper, and draws the manure out through a variable opening. In these machines agitators are generally necessary, as well as scrapers, for the delivery rollers. They are, however, slightly less complicated than the chain delivery types.

All the above-mentioned types draw the manure for delivery from the bottom of the hopper; but there is another type made by Coultas of Grantham, in which delivery takes place from the top, thus obviating the necessity for agitators or scrapers. In this machine the hopper is so constructed that the bottom and front are capable of being gradually raised, being driven by gearing from the main wheels. Situated above the hopper in a

fixed position is the delivery barrel, which is spiked. When the machine is put in gear the delivery barrel rotates, and, dipping into the manure, tips it out over the back of the hopper. It falls to the ground between the back board

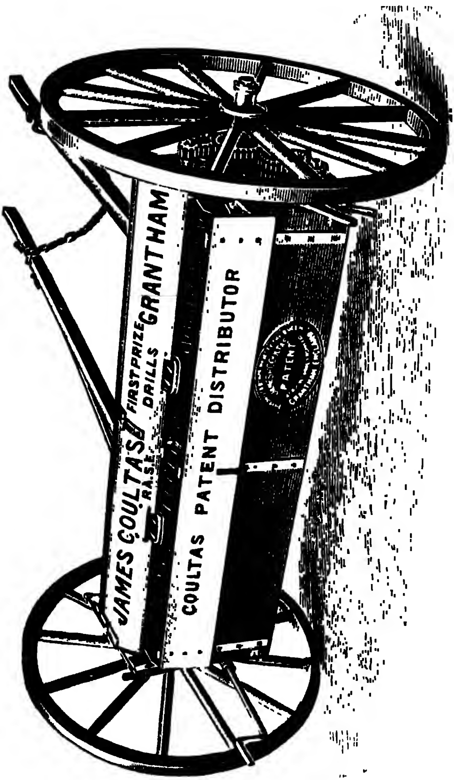


Fig. 49. Coultas manure distributor

of the hopper and an extra outside board which prevents blowing in windy weather. The hopper being raised gradually, the manure is continually brought into the range of the delivery spikes, and by altering the rate of lift the amount sown per acre can be varied.

A number of distributors employ the finger wheel type of delivery. A row of small star or finger wheels are placed along the bottom of the hopper, and these are

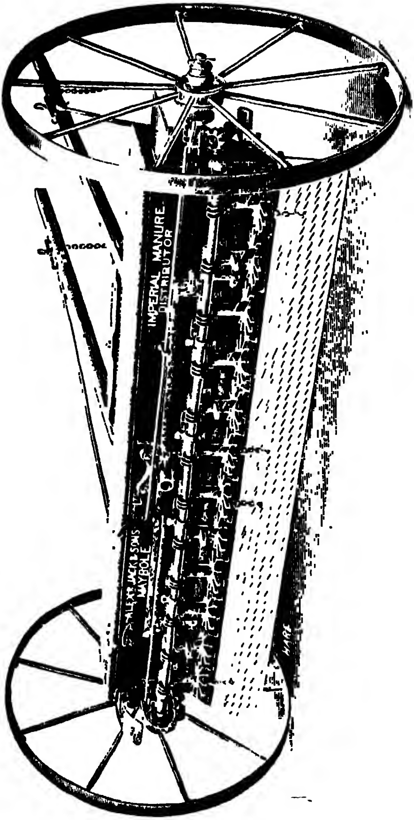


Fig 50 An artificial manure distributor with finger wheel delivery

rotated separately, usually by means of worm gearing. The fingers, moving round, draw out the manure and deliver it through a variable opening. Here, again, agitators and scrapers are necessary.

Most of these machines can be fitted with attachments

for delivering the manure into drills. There are several important features with regard to artificial distributors which should always be looked for when purchasing. Amongst these are the following: There should be a wide range of distribution, some machines being adjustable for sowings of from one-quarter of a cwt. to twenty-five cwts. per acre, and these adjustments must be easy to make. The absence of parts working under the manure is also most important, as is facility of cleaning. The manure should be under cover till it is delivered close to the ground, this allowing the machine to work in wet or windy weather. The general points of simplicity, provision for lubrication, and taking up wear are of course as important as in the case of any other machine. A machine of as large a capacity as is reasonable should always be employed.

Machines of the broadcast type, in which the manure is distributed by centrifugal action, are not to be generally recommended.

Combined drill ploughs and distributors are of value under some circumstances, as, for instance, in potato growing. These machines open two drills and deposit the manure in them. They are, however, of limited application and show practically no advantages over the wide hopper distributor fitted with a drill attachment.

DUNG SPREADERS

The dung spreader is most important where large quantities of farmyard manure have to be handled. It is essentially a low wagon equipped with means for spreading the load. There are several types on the English market, most of which are of American manufacture.

The rear wheels of the machine act a drivers, and provide the power to actuate the various moving parts. In the floor of the spreader is a conveyer, which gradually feeds the dung to the rear of the body as it is spread. Where the floor of the spreader is solid the conveyer consists of a number of cross bars of angle steel mounted

on two side chains. In other cases there is no solid floor, and the conveyer takes the weight of the manure on wooden slats fixed on the side chains. The endless belt passes round a driving drum at the rear. The drum receives its motion from one of the driving wheels, through one of several types of drive, embodying worm gears, ratchet and pawls, or a combination of both. The apron has to move a distance equal to the length of the body once during the spreading of the load. Hence the drive has to include reduction gearing. The rate of spreading is controlled by the speed of the apron, and on this account the regulating lever has to act on the apron drive. Where the transmission includes a ratchet and pawl drive the alteration is usually in the pitch of the pawl. In some cases a face gear is employed to give the necessary alterations.

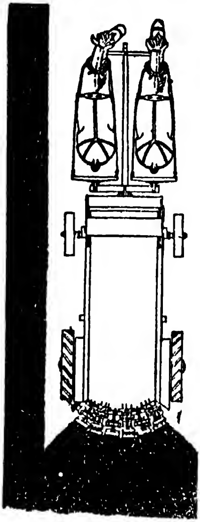


FIG. 51. This illustrates the way the "Fearless" spreads out beyond the wheels on each side. Wheels do not run on strip previously spread

The dung, as it is conveyed to the rear by the apron, comes under the action of the beaters, which tear it up and throw it out from the load. These beaters are of varying form in different machines. In several cases the beaters are simply straight, spiked drums mounted across the spreader. In another the beaters are mounted in a number of separate sections arranged fanwise. This type has the advantage that it spreads wider than the track of the machine without any extra device, whereas the other types require an additional spreader behind to effect this. The beaters run at high speed, and are therefore geared up from the driving wheel. Various types of drive are employed, including bevel gears and chain.

A levelling rake is usually provided, which keeps the load at a constant height when spreading. When loading,

this rake may be dropped in some makes so as to prevent the dung being loaded right on to the beaters. This must be prevented in any case, as otherwise the beaters have no chance to get up speed when the machine is put in gear before they have to deal with the manure. The result is that the machine will probably jam at starting.

Most spreaders hold nearly a ton of average dung, and

FIG. 52. The Walter A Wood Fearless dung spreader at work

the draft is fairly heavy, requiring three horses. The hauling can, however, be very well done by a light tractor, and this method will be found more satisfactory in keeping up a good speed and giving steady operation.

If the spreader is loaded in the yard, the labour saving resulting over the method of carting out to mixens and thence to small heaps for hand spreading, will be very apparent, one handling taking the place of three. In addition to the saving of labour, the spreader shows far-reaching advantages in performing the work much better than it can be done by hand. This means to say that the dung will go much farther than when hand spread, since

an evenly spread dressing is worth from 25 per cent to 50 per cent more to the crop. Furthermore, the rank patches of crop due to the drainage from dung set out in small heaps for hand spreading are avoided. Since these

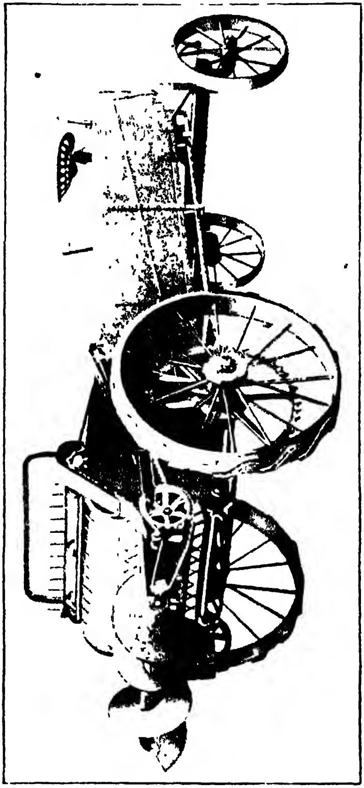


Fig. 53 The International Harvester Company's dung spreader

patches are the first part of a corn crop to lodge in bad weather and affect the rest of the field, it will be seen that the use of the dung spreader involves more than the saving of labour, which alone is a large item.

CHAPTER XI

ROOT GROWING MACHINERY

ROOT THINNERS

THE thinning of root crops for setting is always an expensive matter if done by hand, and to reduce this expense several thinning machines have been produced. It is possible that the most important application of these will be ultimately in the growing of sugar beet.

A good form of root thinner (shown in Fig. 54) employs a hoe wheel for gapping, and is made for working either one or two rows. This wheel is suspended at the back of

TABLE 6

Device or Method	No of Rows	Labour	Acreage Thinned in 8 hours	Cost per Acre s. d.
Symes ..	1	1 man 1 boy	4·0	3 6
Parmiter ..	2	1 man 1 boy	6 6	2 5
Russell ..	1	1 man 1 boy	4·0	3 10
Hand labour, four men ..	—	—	3·9	5 1

an ordinary hoe type of frame, and is not positively driven, but is rotated by the forward motion of the implement. A number of hoe blades are attached to the rotating wheel, and as they move round they enter the row in turn and cut out bunches of roots. This machine is also adjustable to leave larger or smaller bunches as required.

Other machines are on the market in which the gapping

wheels are driven positively by the land wheels, through variable gears. Four turnip thinners were tested in 1922 on sandy soil at Methwold, in Norfolk, by the Ministry of Agriculture. Compared with hand labour the mechanical thinners were found to be much cheaper and a little faster

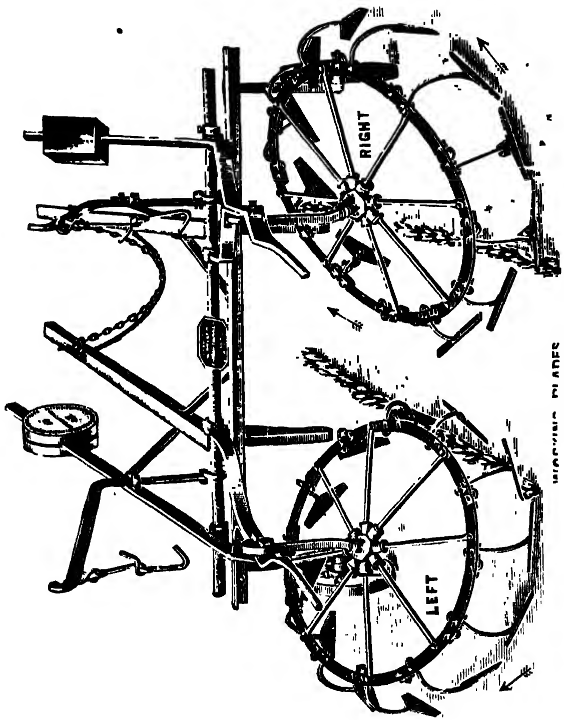


Fig. 54. Parmiter's two-row root thinner

than a gang of four men. Some of the results obtained are set out in Table 6, p. 83.

The lifting of root crops by hand is a tedious and expensive business, and several machines are available for different phases of this work.

THE BEET PULLER

The simplest form of sugar beet puller is built with a short, strong frame, fitted with stilts. A pair of standards carrying small chisel points is designed to run one each side of the roots and loosen them in the ground Higher up the standards are sloping lifting bars, up which the

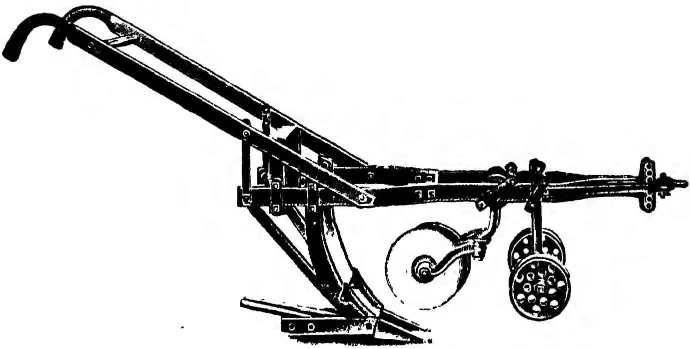


FIG. 55. The International Harvester Company's P. & O. beet puller

beets are forced as the tool moves forward. A pair of gauge wheels are fitted in front, by means of which the depth of working can be altered. If necessary, on account of extra large tops, a pair of rolling coulters can also be fitted.

THE TURNIP LIFTER

Turnip lifters are designed to lift any shallow growing roots, cutting off the tops and tails. The machines may work one or two rows. In one type (shown in Fig. 56) the tops are gathered up by a pair of dividers and gripped by two travelling belts. They are then cut off at the neck by a floating knife. The tails are cut off and the roots lifted out by a rear knife, which travels along under the

row. The depth of working of the latter is easily adjusted by a lever.

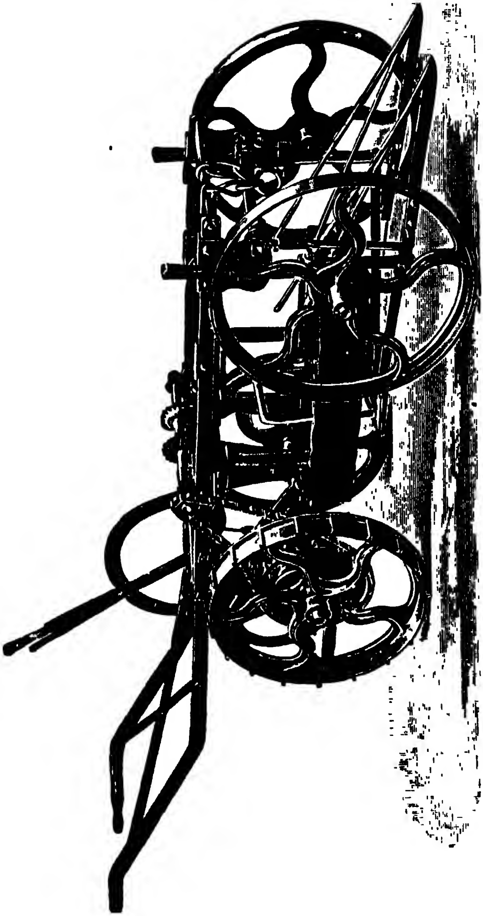


Fig 56. The Teasdale turnip lifter

In the Wigg, designed for lifting two rows, the belt is dispensed with, and the tops, after being cut, are turned

off at each side by two shields. The roots are then lifted by two knives and thrown into one row behind the machine.

These machines were also tested by the Ministry at Methwold, when the data in Table 7 were compiled.

TABLE 7

Device or Method	Percentage Topped	Percentage Tailed	Acreage per Day of 8 Hours	Cost per Acre s.	d.
Teasdale (single row)	77·5	100	4·5	5	3
Wigg (two row)	66·7	—	9·7	2	6
Hand labour (2 men)	100	100	1·2	8	2

The tests took place on a swede crop, and it was reported that several minor defects, which could be obviated, were present in each machine. For example, the Wigg failed to tail the roots owing to badly placed knives.

THE POTATO PLANTER

Although machines for setting potatoes have been on the market for some long time, design is by no means standardized, and improvements are constantly being made. Each make differs widely from others, and it is therefore only possible to describe the general principles on which this class of machine works.

The most expensive part of the planting operation when carried out by hand is the setting. Several makers therefore content themselves with producing a machine which will do this without opening or closing the drills. The machines which are capable of opening the drills, setting the seed, and covering it are, of course, proportionately more useful, as they combine the three operations. There is a further advantage in that damage to the seed, which occurs when horses walk over it hauling a ridging plough in covering, is avoided.

The machines which carry out the complete operation generally plant one or two rows at a time. A double-

breasted baulking plough is fitted at the front to open the drills, while the covering is usually performed by two large discs set at an angle to one another at the rear. On the frame above these parts is carried the hopper, in which the seed is contained. In most machines the seed is removed from the hopper by mechanical means, but in the Albion, made by Messrs. Harrison, McGregor, it is hand fed. The types of automatic feed employed vary,

FIG. 57. A Wallace potato planter in use

but in several cases a form of bucket elevator is used. This is drawn up through the hopper, preferably at one side, and each cup lifts a potato, delivering it down a tube to the ground. In other cases, the seed is picked out of the hopper by highly specialized grippers. By altering the rate of feeding relative to the travel of the land wheels, the spacing in the rows can be varied. Even spacing in the rows is a point necessary to watch. There is a tendency with some machines for the seed to roll along the bottom

of the drill, due to its being dropped from too great a height. The bottom of the drill should be narrow and somewhat V-shaped, in order that the seed will tend naturally to roll into the same straight line.

The ability to sow sprouted seed is not found on every machine, and in this respect the hand-fed machine shows advantages in avoiding damage to the sprouts. Some machines are capable of sowing fertilizer in the drills along with the seed, and this point may appeal to some growers.

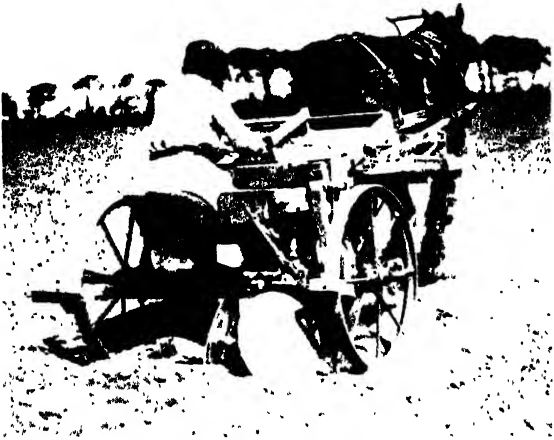


FIG. 58 The Albion potato planter

The potato planter is a most important machine, and one which needs to be developed to a high state of efficiency.

THE POTATO DIGGER

There are now two distinct classes of potato digger on the market, the more recent type being of American origin.

The rotary type of machine, which has been used for a considerable time in this country, and is the more simple design, follows two main lines of construction. The two

land wheels are arranged to run one each side of the row, and provide the power for operating the digger. The power is transmitted through a tail shaft, running fore and aft, to the rotary spinner at the back of the machine. In some cases the drive is taken directly off the axle through bevel gears, while in others spur gears are also employed.

The spinner may be one of two types. In one type the spinner has a number of fixed radial arms, carrying forks at the ends; in the other, link motion is employed, the arms being connected to two points. The usual arrangement is to have two reels mounted eccentrically to one another. The digging forks are mounted on links, which are connected to each reel. Thus they descend into the ground in a vertical position, and lift out the potatoes with a digging action. In other cases a single reel only is used, the inner ends of the digging arms being connected to a small disc.

A large, flat share is borne on a strong standard, and is set so as to run under the ridge below the level of the potatoes. This loosens up the soil and the tubers, leaving them in a loose condition for the digger to throw out. The depth of penetration of the share is adjustable by movement of the standard, while the whole machine can be raised or lowered at the back by means of a lever, which acts through the draft pole. This lever is frequently connected to the clutch, in order that the machine may be automatically thrown out of gear when raised for turning at the ends of the rows. With the fixed type of spinner a check screen is usually fixed at the side to prevent the potatoes flying out too far. In some of these machines the set of the forks is adjustable for different soil conditions. A further adjustment, which is of advantage, is in respect of the speed at which the spinner operates.

The later type of American lifter works on quite a different principle. The share is situated at the front of the machine, and leads up at the rear to the foot of an elevator. As the machine moves forward the potatoes and some of the soil are forced up on the elevator, which

is of open construction. While moving upwards most of the earth falls through the web. At the top of the elevator the potatoes are delivered on to a shaker at the rear, which completes their separation, while a set of oscillating

Fig. 59. The Hoover potato digger, an example of the elevator type

forks above the shaker separates off the haulm. From the shaker the potatoes are delivered to the ground.

There is a number of advantages about this type of machine, and it appears likely to have a big future. Amongst these points are the facts that the potatoes are not subjected to any violent action, and they are delivered

in such a manner that they lie well on the surface in a narrow row. This makes for ease in picking, and leaves the haulm ready to be raked or harrowed up without

TABLE 8

Maximum distance potatoes thrown* (ft.)	(in.)	Number of times the tines enter the ground per 1 revolution of ground wheels	Average draft when lifting	Efficiency of transmission and gearing
4	0	32·4	455	85·7
12	0	24·15	372	77·5
12	0	29·1	363	86·5
9	0	21·8	451	78·1
12	0	31·2	473½	86·3
6	0	31·2	441½	85·2
6	0	31·2	474	85·4

difficulty. The draft is fairly heavy, however, and in individual machines there are some minor improvements desirable.

TABLE 9 (*Elevator Types*)

Machine	Speed in ft. per min.	Ratio between speed of tine chain and wheel	Speed of elevator in ft. per min.	Delivery width	Efficiency of transmission and gearing
Star ..	220	1 : 2·1 1 : 3·1	105 71	1½ ft.	56·3
Hoover ..	250	1 : 1·14	219	1½ ft.	72 2

Potato diggers have been the subject of some important research work at Leeds University. In 1921 ten different machines were tested, and certain of the data obtained are quoted in Tables 8, 9, and 10.

TABLE 10 (*Rotary Types*)

Machine	Labour: On machine tractor	Labour: Picking	Area lifted by machine	Weight lifted by machine	Percentage lifted of estimated total	Percentage damaged of weight lifted	Total weight of harrowings lift	Area lifted and picked
			Acres	T. cwt. qrs. lb.			T. cwt qrs.	Acres.
Ransome	2	13	4	46 16 2 7	91·2	1·197	2 15 0	1·7
Bamlett	2	14	5	60 6 3 12	88·68	0·487	4 2 2	2·2
Powell	2	14	3·2	40 8 3 15	90·0	0·353	2 12 2	1·4
Martin	2	14	4·7	56 19 1 6	91·21	0·671	4 8 3	2·1
Jack's Imperial ..	2	14	3·2	39 18 2 5	91·23	0·293	1 16 0	1·5
Jack's Caledonian, A	2	14	3·4	43 0 0 19	89·33	0·469	2 17 2	1·6
Jack's Caledonian, B	2	14	4·2	48 9 0 20	87·17	1·263	3 1 0	1·9
(Elevator type) Hoover	2	11	3·5	39 17 0 16	89·12	2·422	1 4 3	1·7
Star	2	12	3·0	32 2 0 16	73·84	3·822	2 12 2	1·4

As regards cost per acre, the Martin was lowest at £5 9*s*. 3*d*.; and all the rotary machines were cheaper than the other types. The first six in order of mechanical

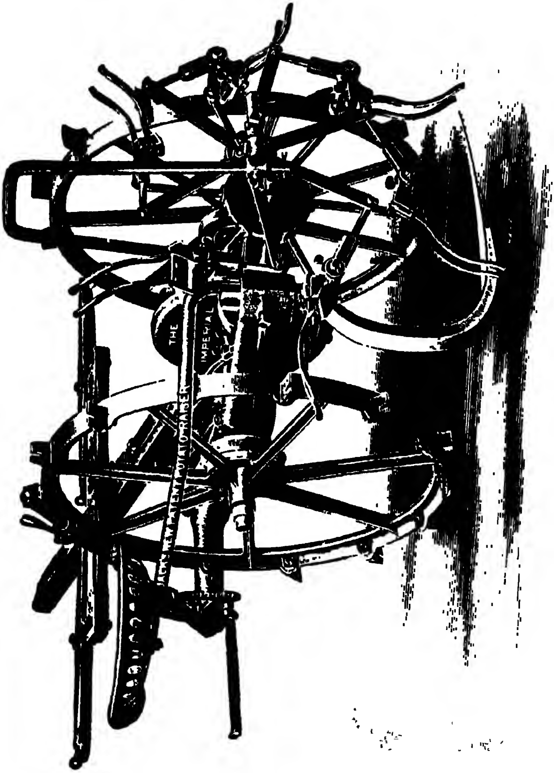


Fig. 60. Jack's Imperial potato digger

efficiency were rotary types, headed by Jack's Imperial. The Hoover required the least time for picking up the potatoes; and this illustrates the advantage of this type in depositing the tubers in narrow rows. The greatest amount lifted per day was by the Bamlett, with 60¼ tons.

Ransome's digger lifted the highest percentage of the crop in the ground; while Jack's Imperial showed the lowest percentage of damaged tubers.

The effect of varying speeds of operation was noted

TABLE II

Machine	Ratio between spinner and ground wheels	Average speed of machine in feet per minute	Average number of revolutions of spinner per minute	Angle of penetration of tine	Depth of penetration	Average width of delivery	
					ins.	ft.	in.
Ransome's	5·4 : 1	230	134·7	8°	8	3	3
Bamlett	4·83 : 1	300	153·2	9°	8	4	3
Powell	4·85 : 1	241	124·0	3	8	5	0
Martin	5·15 : 1	272	140·0	10	8	4	3
Jack's Imperial ..	5·2 : 1	187	92·0	45	8	5	0
Jack's Caledonian, A	5·2 : 1	210	107·3	30°	8	4	6
Jack's Caledonian, B	5·2 : 1	200	120·1	30°	8	4	0

with regard to width of delivery and freedom from damage to the potatoes. Increased speed was noted to have an adverse effect on both these factors.

THE POTATO SORTER

A good sorter is practically a necessity wherever potatoes are regularly grown. The sorter is usually designed to remove dirt from the tubers and sort them into three sizes—ware, seed, and chats. This is effected by passing the potatoes over a series of screens. Delivery of the ware or saleable potatoes generally takes place on to an elevator, which leads the potatoes into bags. The other two sizes are most commonly delivered out of chutes on to the ground or into baskets, but in some cases the seed can be bagged direct over a second elevator.

The screens may take the form of flat riddles or a long circular cage, on the same principle as a rotary corn screen. The necessary power for operating the working parts may

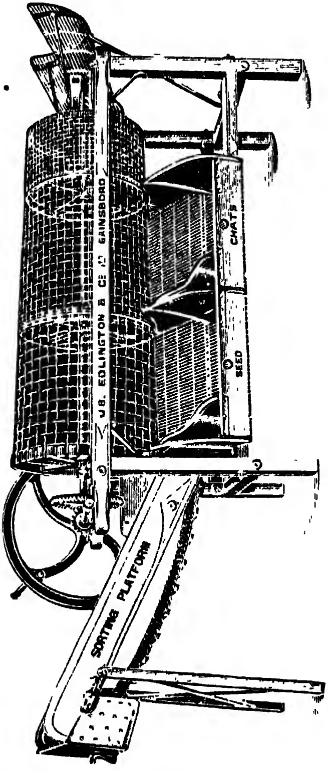


Fig. 61. An Edlington potato sorter for hand or power operation

be supplied by hand or by a small engine fixed on the frame, this method reducing the hand labour required. The filling hopper should not be placed too high off the ground, as difficulty may occur in lifting the potatoes into it.

CHAPTER XII

THE GRASS MOWER

THE modern mowing machine has been developed to a high state of efficiency, and providing reasonable care is given, the best makes give many years of good service.

For the purpose of examining the construction of the mower we may divide it into the following sections: the

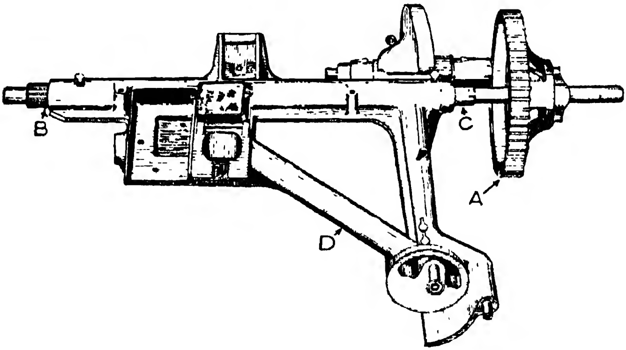


FIG. 62 A typical frame as employed on the McCormick machines

A, The main spur driving gear, which takes power off the land wheel; B and C, Roller bearings on the main drive shaft; D, Brace bar which gives strength and rigidity to the whole frame

frame, the wheels and gearing, the cutting mechanism, and the controls.

The design of the frame is very important, since it is responsible for carrying the cutter bar and also for keeping all the driving gears in correct alignment. In addition, all the haulage and other stresses fall upon the frame.

Hence the chief points to be looked for are great strength, combined with the necessary rigidity to keep the gears and shafts in their correct positions. On this account the majority of mower frames are cast in one piece and follow the general shape shown. The hollow tube which forms the rear member of the frame serves as a housing for the main axle, which carries the two driving wheels. At right angles to this, and passing forwards, is the casing for the crank shaft, which transmits the power to the cutting mechanism. In the centre of the frame is a socket to take the end of the draft pole. Suitable brackets are provided to carry the necessary levers, and the rest of the frame is made up of brace bars to strengthen it.

The method of taking the drive from the wheels varies somewhat in the different makes. One type employs one or two large gear rings mounted on the driving wheels, and having teeth on the inside. A small pinion meshes with the gear ring and is driven by it. The small pinion (or pinions) is mounted on a countershaft carried in bearings supported in the main frame. On this shaft is mounted a bevel gear wheel and a clutch, which allows of the bevel pinion being fastened rigidly to the countershaft when required. The bevel gear meshes with a smaller bevel at right angles to it, the latter being fixed on the upper end of the crank shaft. In another method of arrangement one large spur wheel with external teeth is carried on the axle, and a small pinion on the countershaft meshes with it externally. Thence the transmission of power is practically similar to the example given above.

The chief advantage of the first method is that there is a larger number of teeth engaged at any moment, and therefore there is less strain on them, giving a longer life. In either case the main wheels drive through a ratchet and pawl connexion. This allows of the wheels turning independently of one another, and also permits the machine to be backed without driving the crank shaft.

Roller bearings are commonly employed for the main axle, and in some cases on the countershaft. To keep the

bevel gears correctly meshed, the gear shaft is usually provided with a ball thrust bearing, which is adjustable,

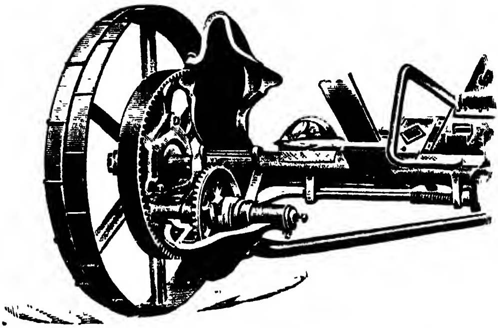


FIG. 63. Driving gears of a Walter A. Wood mower. Internal driving gear ring type

and can be screwed in to bring the gears closer together when wear has taken place. The crank shaft is carried

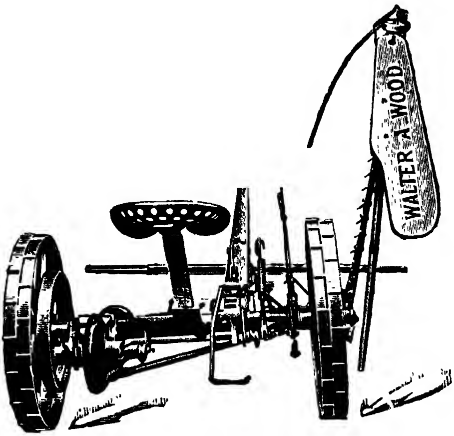


FIG. 64. A vertical lift mower

in plain bearings, which may have renewable soft metal liners. Roller bearings are not suitable for this position

since the bearing is subjected to a continuous hammering action. The gear end of the shaft is generally furnished with a ball thrust bearing.

The forward end of the crank shaft carries a crank and crank pin, which fits into the end of the pitman or connecting rod. The rotary motion of the crank shaft is thus converted into reciprocating motion and transmitted to the knife. A protecting bar, forming part of the frame, should be arranged across the machine, parallel with the pitman and in front of it, to act as a guard. This saves the pitman and knife from damage in the event of striking an obstruction. A balance weight is fitted to the end of the crank shaft to ensure even running of the pitman.

The cutter bar carries all the parts actually concerned in the operation of cutting. All the parts are built up on

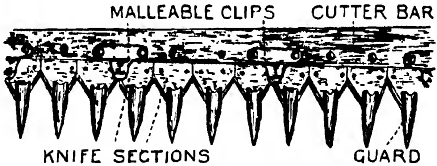


FIG 65. Section of a typical cutter bar

a flat steel bar, which tapers in width from the inner end outwards. The cutter bar is hinged to the frame at the inner end by means of one or two hinge pins, which pass through accurately drilled holes in the frame coupling and the bar hinge. These pins must be heavy and well fitted, as the condition of the hinge coupling has a most important effect on the working of the machine, as will be explained. The coupling is held on one end of the push bar, one member of the frame. This extends across the machine from the back axle, and is usually adjustable. The arrangement of this member varies considerably, and in some cases it is not employed at all.

Attached to the front of the cutter bar are a number of fingers or guards which project forwards from the

under side of the bar: Fig. 67 shows the general design of mower fingers. The ledger plate is a specially hardened piece of steel let into the guard, and this forms one-half

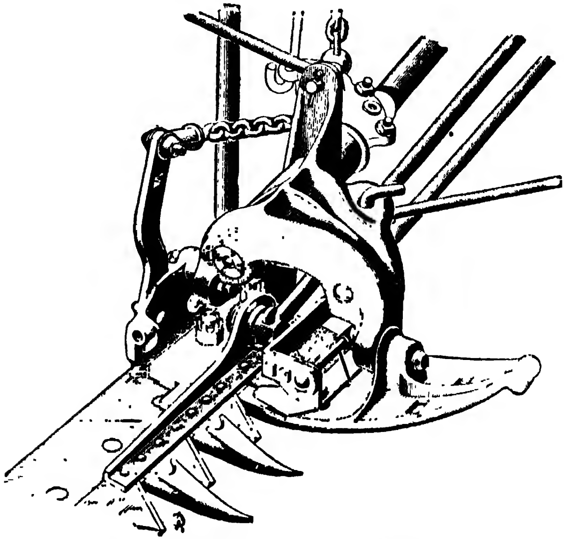


FIG. 66. Inner shoe of a Massey-Harris mower, showing hinged coupling

of the actual cutting apparatus. The knife, or sickle as it is sometimes called, is built up on a steel back about the same length as the cutter bar. The cutting edges are

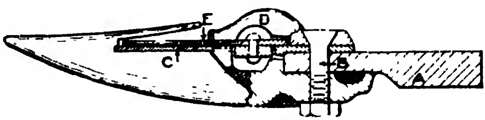


FIG. 67. A typical mower finger

A, cutter bar; B, holding-down bolt; C, ledger plate; D, malleable clip; E, knife section

formed on two sides of a number of triangular knife sections, which are riveted to the back. One end of the knife carries a large eye, into which fits the hook or wrist

pin of the pitman. Thus a driving connexion is made between the crank and the cutting mechanism. In some

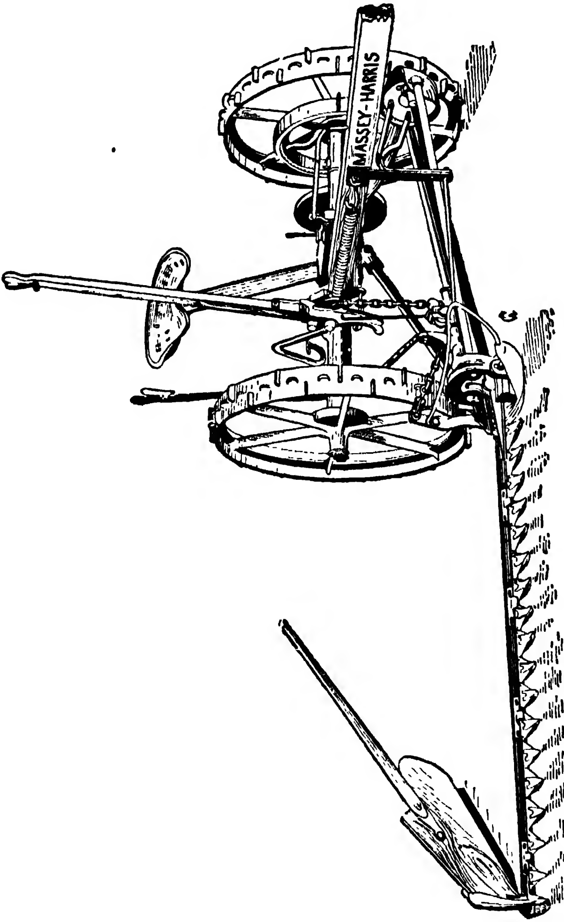


Fig. 68. A Massey-Harris mower

cases the connexion is made by a ball and socket joint at the knife head, instead of the hook and eye. The pitman

hook is retained in position by means of a latch placed on the cutter bar.

As the knife moves to and fro by the action of the pitman, the knife sections pass over the ledger plates, and thus cut the grass with a shearing action. Both edges of each section take part in the cutting. It will be seen that to cut efficiently the knife must be held closely against the ledger plates. This is done by means of several clips fastened to the back of the cutter bar and projecting over the knife. These are malleable and may be hammered down on to the knife to ensure its close setting. This operation is necessary only after wear has taken place. Too close a setting will cause running hard and undue wear. To take the wear due to the constant rubbing motion of the knife back, hard steel wearing plates are frequently placed on the cutter bar, and the knife slides on these. The plates can be cheaply renewed when much worn.

The knife speed is an important factor in cutting, and varies according to the gearing of the crank shaft drive. At a travelling speed of 2½ m.p.h. the pitman wheel revolutions on horse mowers range up to about 800 r.p.m. High knife speeds are necessary when cutting thick crops, but are not desirable when there is little resistance to cutting. Hence some mowers are fitted with two-speed gears, a very useful feature.

When operating, the cutter bar lies on the ground, and its weight is partially carried by shoes or wheels placed at each end, these being adjustable to allow of cutting at different heights. The shoe is much preferable to the wheel, if a large, well-designed pattern is used; the shoe gives lightness in draft, showing an advantage over the wheel of about 13 per cent. For efficiency on undulating ground it is essential that the cutter bar should be very flexible, and be free to rise and fall at its outer end.

The outer end of the cutter bar carries a large divider guard, and a grass board hinged to it projects to the rear. These serve to divide the grass to be cut from the rest of the crop and to lay it over in a swath after cutting. This

latter action is further assisted by the grass stick, which is mounted on the swath board. These can be adjusted for different cutting conditions.

In order to raise the cutter bar from the ground when necessary, a system of lifting gear is provided, being operated by hand and foot levers. Incorporated in this system is a strong spring, which is connected up in such a way that it supports most of the weight of the cutter bar when the latter is on the ground. Thus the lifting levers are relieved of the bulk of the work in raising the

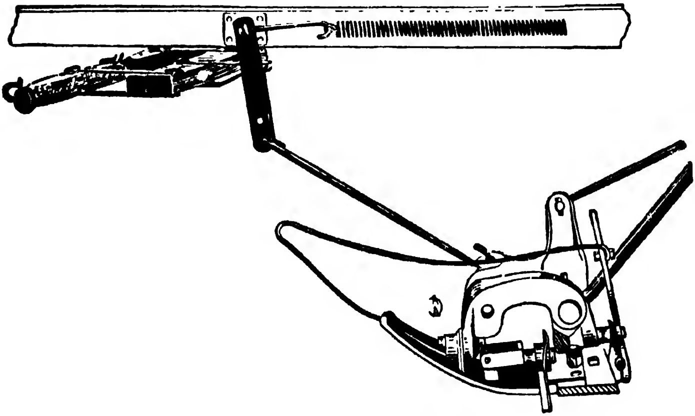


FIG. 69. Under draft link as employed in Massey-Harris mowers

bar. The foot lifting lever generally raises the bar for a short distance, just sufficient to clear the ground for turning at the corners, etc. By means of the hand lever the bar can be raised to an angle of about 35° to 45°. In some cases the cutter bar can be lifted to the vertical position by the hand lever. Such machines are very useful for cutting amongst trees or other frequent obstructions, and are also a good type for hillside cutting. Where vertical lift is not fitted it is necessary to raise the bar by hand, and hook it up when it requires to be held in the upright position for transport.

For efficient working under varying conditions it is

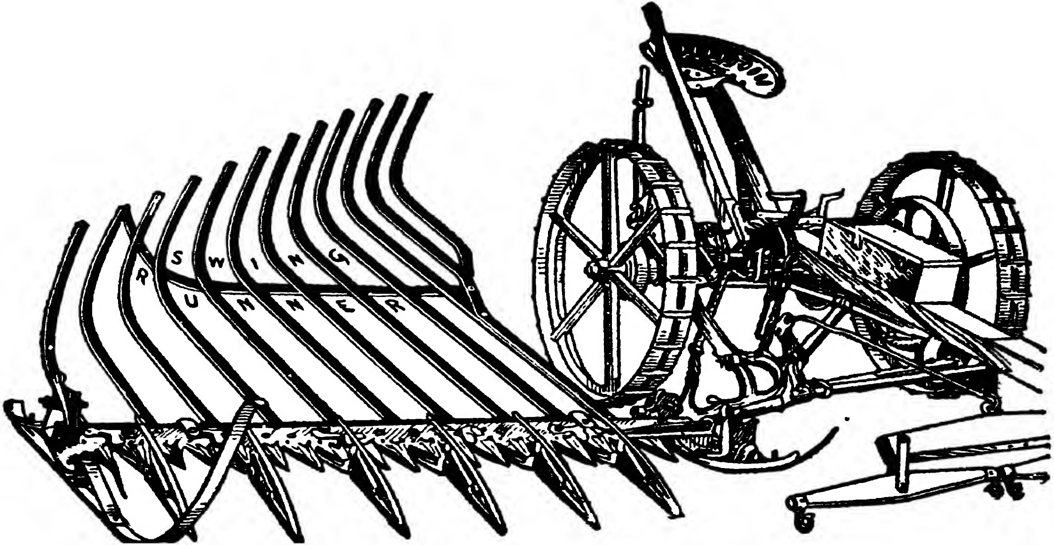


Fig. 70. The King pea harvester attachment

necessary to be able to alter the angle at which the cutter bar is set. This means pointing the guards up, down, or

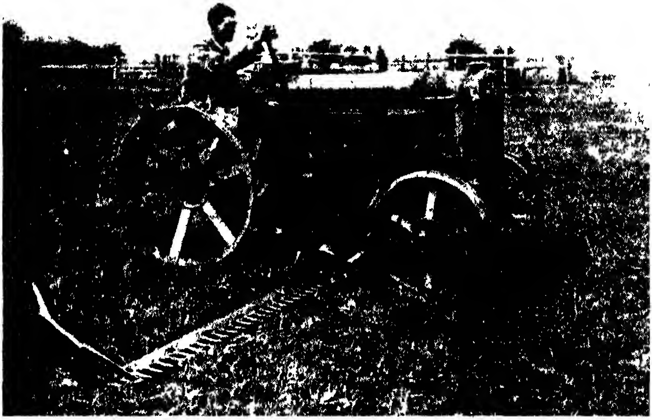


FIG 71. The Roderick Lean Cutmore mower attachment for the Fordson

horizontally. This is usually accomplished by means of a small hand lever, which is connected by a link to the

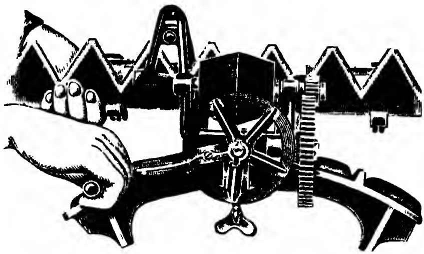


FIG. 72. A sickle grinder made by Messrs. Walter A. Wood

bar, the latter pivoting on the push bar. In some cases the small wheels on the cutter bar are adjustable, by means of snubbing blocks, to alter the pitch of the guards.

The draft is taken by a pole, which fits into the socket on the main frame. In addition, most mowers are provided with a link attached to a point near the hinge coupling, which joins the draft pole. In this way the cutter bar is both pushed and pulled. If suitable precautions are not taken there is sometimes a tendency in heavy work for the inner wheel to rise from the ground. The underdraft

TABLE 12

Machine	Traction load in lbs	Increase in load due to		Pitman wheel R.P.M. at			Forward movement of tractor in inches for each revolution of pitman wheel
		Gearing	Cutting	2 m.p.h	2½ m.p.h	3 m.p.h	
Albion	—	—	—	600	750	900	3 5
Bentall (Experimental	536	10·6	11·6	610	760	910	3·5
Bentall (2 machines)	573	19·0	27 9	—	—	—	—
Cutmore †.. ..	800*	5·0	9·1	380	470	560	5·6
International ..	1,042*	5·9	11·3	520	650	780	4·1
Otwell	802*	11·6	20·2	530	660	800	3·3
Taco-Myers ..	850*	6·5	9·0	570	710	850	3·2

link helps to overcome this. Any standard mower can be used with a tractor by substituting a short draft pole for the ordinary long one used with horses.

By employing a special pea harvester attachment, comprising extra large guards and a number of steel windrowing slats, the mower can be successfully used for cutting peas.

* Including draft of tractor

† This machine has two different driving sprockets, that giving the lower knife speed being used for this test. The smaller sprocket increases the knife speed by forty per cent.

Cutter bar attachments for light tractors have now been developed to a high state of efficiency. These attachments enable the whole of the work to be done by the tractor driver, and dispense with a separate frame.

The pitman is driven through suitable transmission by the tractor engine, and there is thus no loss of power, such as occurs in picking up power from the ground by the traction of ordinary mower wheels. It should be noted that when the power take-off for the mowing attachment is situated on the engine side of the tractor transmission gears, the speed of the knife can be altered with relation to the rate of travel; whereas if the take-off is from the final drive of the tractor, the knife speed has a constant ratio to the rate of travel.

Trials of mowing machines and attachments were held by the Ministry of Agriculture at Colchester in 1922, when the lowest cost per acre was 1*s.* 10*d.* for the Fordson tractor with an Otwell attachment. Horses with an Albion mower cost 3*s.* 4*d.* per acre. Some of the chief results are given in Tables 12 and 13.

Troubles very seldom arise, except from accident, when mowers are kept in good repair; but as this is not always the case, a summary of the chief faults, with their causes, is set out below:

MOWER TROUBLES

Fault	*Cause*	*Remedy*
Heavy draft	Lack of lubrication	——
	Blunt knife	Keep spare knife sharp.
	Non-alignment of cutter bar	Adjust. Can sometimes be overcome by shortening drawbar and lengthening push bar.
Uneven cutting	Poorly adjusted cutter bar	——
	Guard out of line	Straighten.
	Clip worn, not bearing sufficiently on knife	Tap down lightly with hammer.
	Loose knife section ..	Tighten up rivets.
	Loose guard	Draw up nuts.

MOWER TROUBLES—*Contd.*

Fault	*Cause*	*Remedy*
Uneven cutting —*Contd.*	Pitman wrong length, and knife not registering	Adjust. Where no adjusting device, replace by pitman of correct length.
Clogging of cutter bar	Broken section	Replace.
	Oiling knife parts which are wet with sap, causing gumming up	Oil only parts which run dry, especially knife head.
Broken section	Stones	Raise cutter bar if trouble persistent.
	Bent guard	Straighten guard.
Broken knife	Worn crank-shaft bearing, leading to jerky pitman action	Renew bearing.
	Worn crank pin or pitman eye or hook	Renew.
	Worn clips and wearing plates at inner end of cutter bar, allowing up and down play of knife	Renew.

TABLE 13

Machine	Power	No. of men required	Width of cut	Average speed in m p h.	Acres cut per hour
			ft. ins		
Albion	2 horses	1	5 0	1·2	0·75
Bentall Experimental Horse Mowers	Fordson	2	4 6	2·0	1·09
2 Bentall Horse Mowers	Fordson	3	8 6	2·4	2 48
Roderick Lean Cutmore	Fordson	1	6 0	2·2	1·58
International Harvester	International Junior	1	7 0	1·4	1·21
Otwell	Fordson	1	6 0	2·1	1·51
Taco-Myers	Fordson	1	6 0	2·1	1·51

CHAPTER XIII

HAY HARVESTING MACHINERY

HAY MAKING MACHINERY

The Swath Turner

THE swath turner is one of our most important hay making implements, and a considerable amount of hay is cured almost entirely with the help of this tool.

The reversible type employs two sets of forks mounted on separate heads, one driven from each wheel. The forks are attached by links and descend in a vertical position, similar to the action of a potato digger. These machines can generally be set to turn two swaths to the left or the right, and also inwards or outwards. It is thus possible to make small windrows. These machines can of course follow equally well a right- or a left-hand mower.

A different type of turner employs four horizontal rake bars carrying a number of vertical teeth. These bars are mounted at each end on a rotating disc, and are usually set obliquely across the frame, either in front of or behind the driver's seat. The rake bars operate with a sweeping motion, and for swath turning the teeth are used on the ends of each bar, but not in the centre. This type of swath turner is one variation of a combined machine of which the primary work is side raking.

The Side Delivery Rake

The side delivery rake is constructed as described in the above section, on the swath turner. For side raking

however, the teeth on the rake bars are carried right across the bar without any gap. This machine can be obtained in its combined form or simply as a side rake, to be used

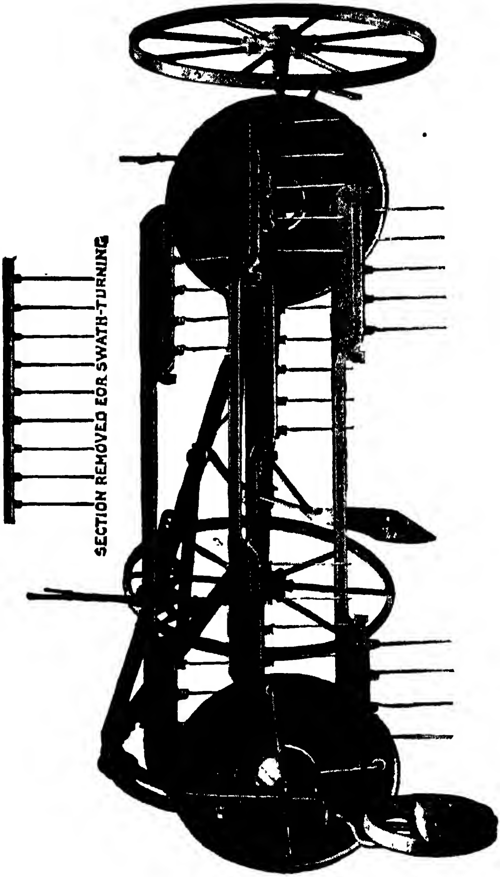


FIG. 73. A Bamford combined hay maker, fitted for swath-turning

for windrowing. It will cover two swaths, and thus in one bout across the field will put five swaths into one windrow.

The Tedder

The tedder is used for breaking open the swath and leaving it hover. The use of the tedder is usually necessary only when the swaths are very tightly packed, as after they have been rain soaked ; and the objection to its use is the more or less rough treatment the hay receives. The least objectionable type on the score of rough treatment is the kicker, which employs spring forks mounted on cranks. A back kicking action is thus obtained.

The " Lion " tedder is an original type, having spring teeth mounted on wide bars placed at right angles to the line of travel. The ends of the bars are carried on two discs situated to the rear of the axle, and the rotation

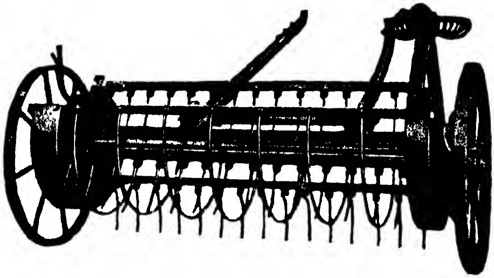


FIG. 74. Bamford's " Lion " tedder

being eccentric, the necessary action is obtained. These tedders are gentle in action.

The combined hay makers have become very popular, since they have been developed to a high state of efficiency. They are built on the lines of a side delivery rake. For swath turning the centre sections of teeth are removed, while for tedding the direction of rotation is reversed. Where the acreage of hay is not very great one of these combined machines will do the whole of the work.

The Self-Dump Rake

The self dump rake is used for collecting any hay left

after carrying, and can also be used for windrowing. It consists of a large number of curved teeth carried on a bar mounted parallel to the axle. In action the teeth can be

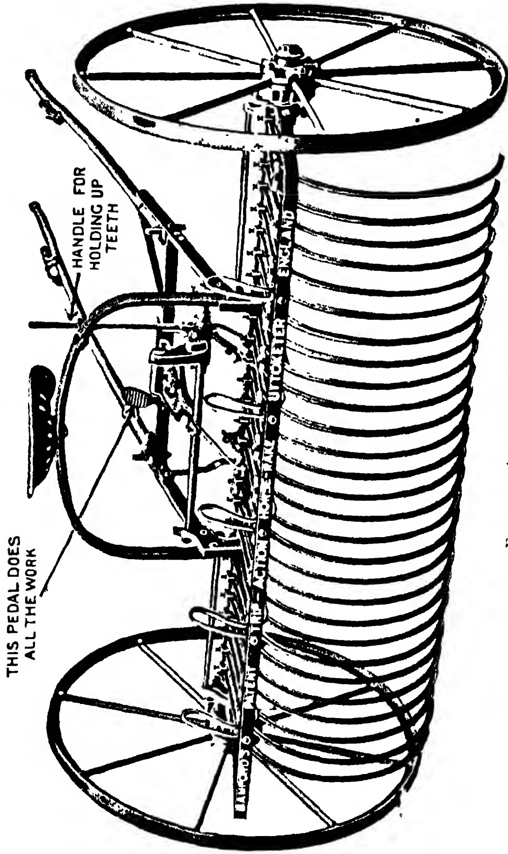


Fig 75 A typical horse rake

set as close to the ground as desired. To deposit the load the operator depresses a foot lever, which brings a pawl on each end of the dump rod into engagement with a

ratchet gear in the wheel hubs. Cleaning rods are provided which strip the hay from the teeth as they rise.

HAY CARRYING MACHINERY

The Hay Loader

The hay loader is of great value when the hay is to be carried out of the field to be stacked as it saves much time and labour in loading wagons. There are two chief types, which differ in the method of lifting and elevating the hay.

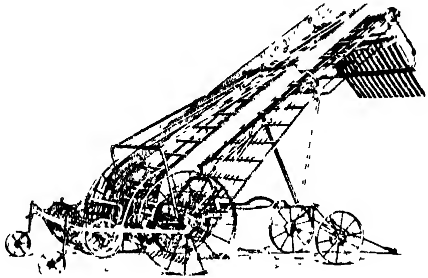


FIG. 7? The McCormick apron type hay loader

The apron type of loader employs a light frame of angle steel carried on two large wheels at the rear, and supported on a swivelling fore carriage in front. A short draw bar enables it to be hitched to the wagon. Mounted on the main axle is a large gathering drum, which carries a number of spring teeth, loosely mounted so that they hang downwards when at the lower side of the drum. These teeth pick up the hay as the machine is drawn forward. Passing round the drum is the elevating apron, which also passes round pulleys at the top of the machine. This apron is of open construction, being built up of cord and wooden slats on two chains As the drum carries up the hay it is passed on to the apron, when each set of teeth

reach the top of their travel. The hay is then carried on up the elevator on the apron and delivered on to a slat platform at the top, whence it falls to the wagon. It is held on the apron by means of shallow wooden sides and top slats.

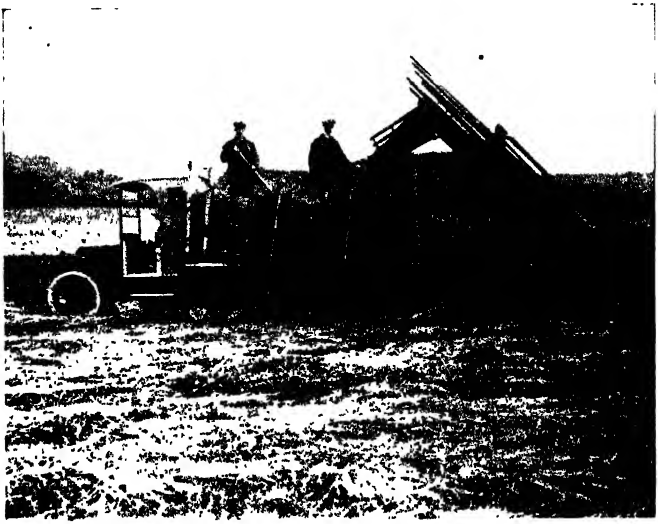


FIG. 77. Carrying hay with an Oldsmobile one-ton truck and a Massey-Harris fork type hay loader

To gather any hay which may be left by the main drum, a gleaning cylinder is placed at the rear. This carries several rows of raking teeth, which rotate in the opposite direction to the main drum, and thus throw any hay left on to the drum. If this gleaning cylinder is correctly set it generally removes the necessity for raking after carrying operations are completed.

To throw the machine in or out of gear, clutches are provided in the hubs of the wheels. The wheel boxes are also provided with ratchet and pawl mechanism to allow of turning without dragging.

Another type of loader employs reciprocating forks or rakes to perform the elevation. These machines are constructed chiefly of wood, the frame forming a flat platform with shallow sides. This platform extends down to the ground and the hay is lifted on to it by the forks. These are mounted on two crank shafts placed across the platform and driven by chains from the main wheels. Each rake bar has a fork at the bottom and a row of prongs throughout its length. The crank shaft may be either two or three throw, and the reciprocating action of the bars pushes the hay up the platform and delivers it over a hinged platform at the top.

The loader can pick up from windrows or swaths, two of the latter being taken. It is usually more satisfactory to load from the windrow. Two men are required on a wagon to load, but the loader requires practically no attention. To enable the load to be packed on rapidly, special racks are needed when working with a loader. These simply consist of high rope and slat sides and front to hold the hay in place. These racks are quite cheap to build or buy.

The Hay Sweep

The hay sweep should be used when stacking in the field. The sweep consists of a wooden frame with a set of long wooden teeth projecting forwards. A wheel is situated at each side of the frame, with a swivelling wheel behind. The teeth can slide on the ground or be raised slightly. They are shod at the points in such a way as to remove the tendency to stick into the ground when moving forward. A pole is placed at each side of the frame, to which the whipple trees for the hitching of a pair of horses are attached. The sweep is driven forward with the teeth lying on the ground so as to slide under the hay, which may be picked up from the swath, from windrows, or from cocks. The hay gradually piles up on the sweep, and when a full load is obtained the teeth are swung up

just clear of the ground and the sweep driven to the stack. By dropping the teeth and backing away, the operator

Fig. 78. Mugleston's hay sweep.

deposits the load on the ground, whence it is usually put on the stack by means of an elevator. The hay sweep

offers a very quick and economical method of carrying the crop when stacking in the field. It can be successfully hauled by a light tractor if hitched by means of two long chains. This tool has also been used for carrying sheafed corn by simply sweeping up the shocks.

CHAPTER XIV

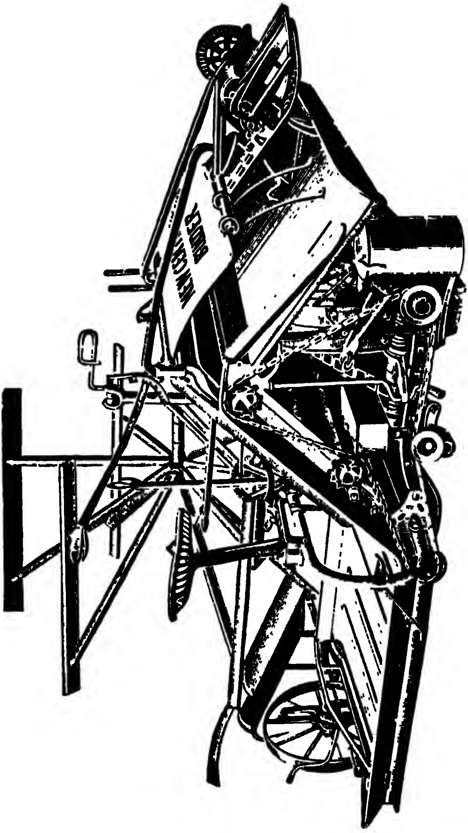
THE REAPER AND BINDER

THE binder of to-day is a remarkable piece of machinery, comprising, as it does, a very large number of components for carrying out different stages of the work. Thus, although the parts are comparatively simple when considered separately, the whole forms a somewhat complex machine.

The main frame which forms the skeleton of the binder is built up of channel or angle section steel, strongly braced and riveted. A rectangular opening is provided for the slinging of the main driving wheel of the machine. The frame is extended considerably to one side of the main wheel to carry the platform. The superstructure above the main wheel carries the elevators, binding table, and the necessary gearing.

The cutting mechanism consists of a cutter bar similar to that of a grass mower, which is rigidly fixed on the front of the platform. The driving power for this and other parts is taken off the main wheel through a large chain sprocket fixed to the hub. From this a short chain conveys the power to a countershaft, which is situated behind the large driving wheel and parallel to its axle. On this countershaft is placed the main clutch, by means of which all the moving parts can be thrown into or out of gear. The extremity of the shaft carries a bevel gear, by means of which the drive is transmitted to the crank shaft. The latter lies along one side of the machine in a fore and aft direction. The forward end carries the crank, to which is attached the eye of the pitman, by which the knife is operated.

On a binder the cutter bar runs quite clear of the ground, being, as mentioned above, attached to the platform,



which is supported at the outer end by the divider wheel. The height of the cutter bar above the ground is set by

adjusting the two wheels before starting, and a tilting lever is provided by means of which the angle of the

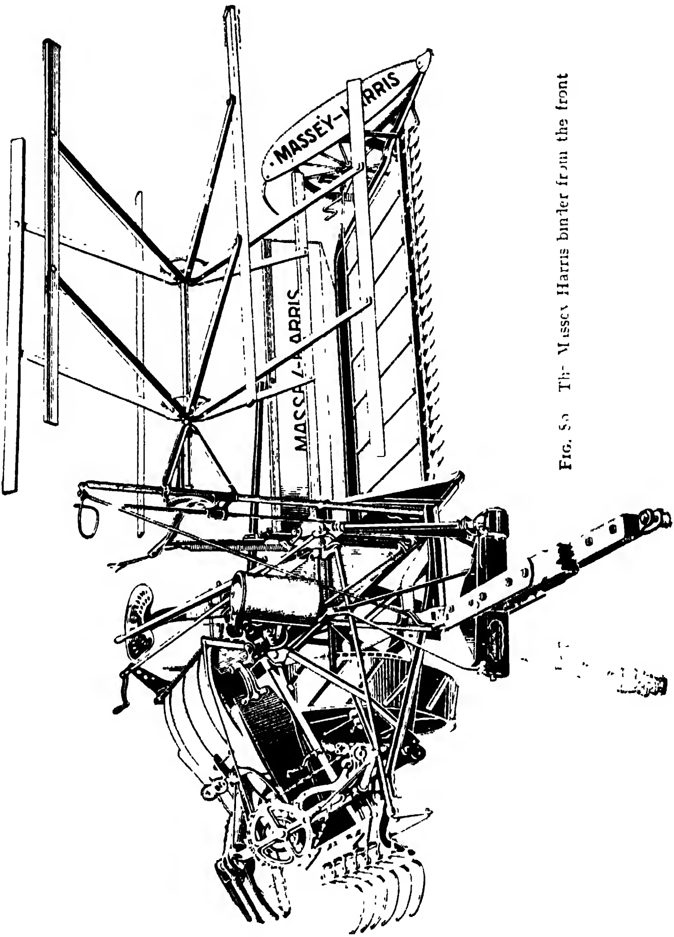


FIG. 59. The Massey Harris binder from the front

platform can be altered at will. The main wheel usually works up and down in a pair of racks, the axle being fitted

with corresponding pinions, which mesh with the teeth of the racks. One end of the axle carries a worm wheel, and meshing with this is a worm on the end of a rod, carried out clear of the machine and provided with a handle. By turning the latter the requisite movement of the main wheel in its racks is effected.

To hold the grain against the knife a reel is used. This carries a number of bars or sails, fixed parallel to the cutter bar, and is rotated on a horizontal axis. At the

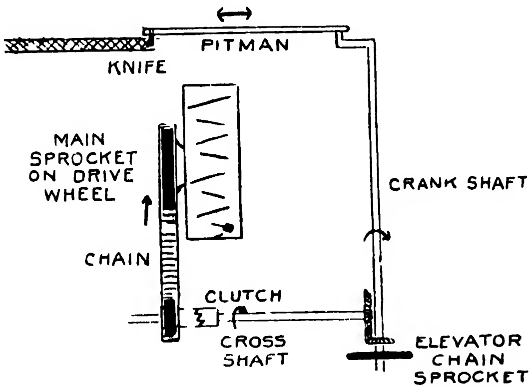


FIG. 81. The general lay-out of a binder main gearing

inner end the reel spindle is attached to a well-braced standard, which takes the whole weight, there being no outboard bearing as a rule. Thus a certain amount of sag in the reel is inevitable, but to take this up as much as possible an adjustable stay is employed to brace the standard. The reel is driven through a set of bevel gears, the final driving pinion being mounted on a square shaft, on which it is free to slide. This is necessary because the reel has to be made movable in order to deal successfully with different conditions of crop. By means of a lever situated close to the operator's seat the reel can be moved

up or down and backwards or forwards. By skilful manipulation of the reel the operator can usually pick up

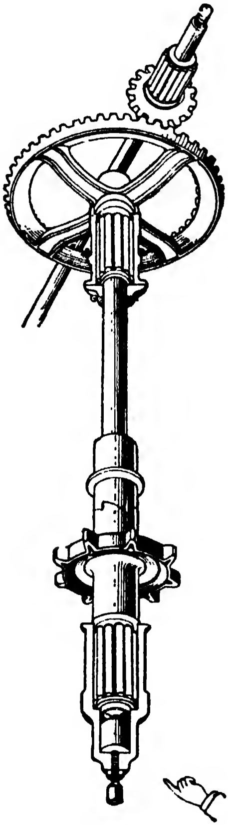


Fig. 82. The first motion shaft of a Massey-Harris binder showing the adjustment for keeping the bevel gears in mesh, and the dog clutch

corn which is lying away from the knife, unless it is very badly laid. The motion for the reel drive is usually taken from the upper elevator roller. Two shafts and several

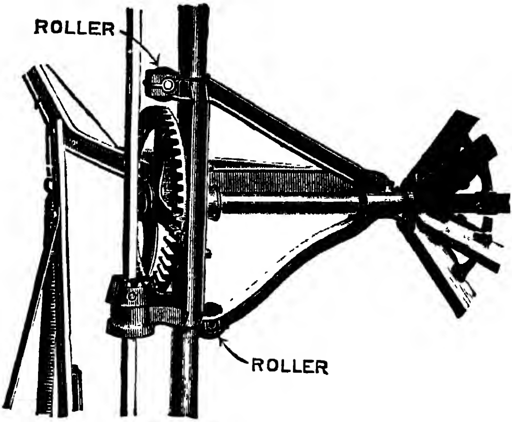


FIG. 83. Upper end of reel drive, showing the reel rollers

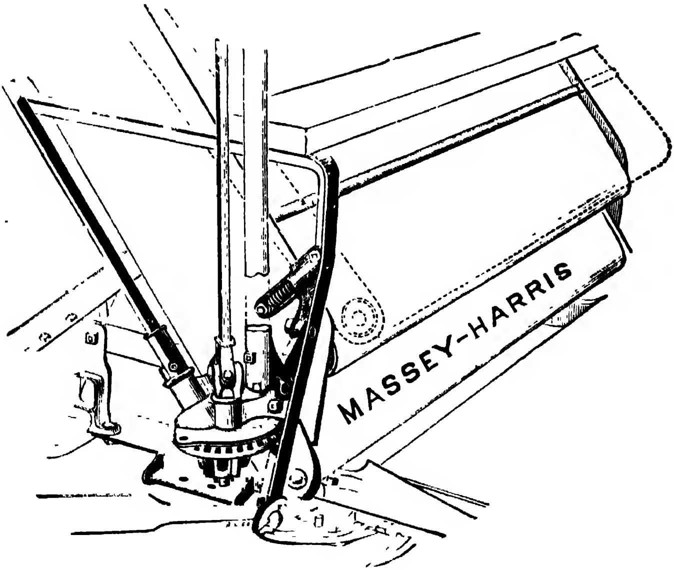


FIG. 84. Lower end of the reel drive

universal joints have to be employed in this drive. In some cases chain drive is employed instead of the type described above.

After being cut the grain falls on to the platform.

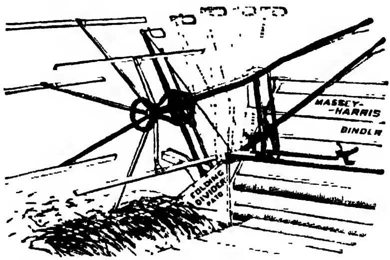


FIG. 85. Diagram showing how the position of the reel may be altered

This is built up of sheet steel on an angle steel frame. At each end is situated a roller, the inner one being driven. Around these passes an endless canvas, which moves towards the elevator. Thus as soon as the corn falls on the platform it is conveyed across to the elevator.

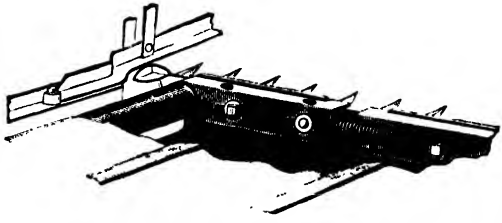


FIG. 86. Section of the platform on a Massey-Harris binder, showing spring canvas tensioner

The elevator comprises upper and lower canvases. Each of these passes round and is driven by rollers set in wooden frames. The upper frame is floating, so that it can rise and fall to accommodate varying quantities of

grain. The driving rollers are at the top and are geared together, the two ascending sides of the canvases being on the inside. Thus the corn is gripped between the two surfaces and carried up to the top, where it is discharged over a seventh roller, which aids in easy delivery. The power for driving the rollers is transmitted by a long chain, passing over a sprocket at the end of each driving roller and round a driving sprocket at the end of the crank shaft. The distance between the rollers of each canvas is usually

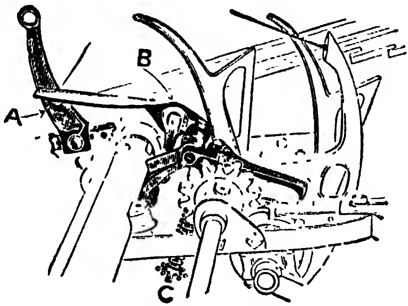


FIG. 87. A, the compressor arm; B, the trip lever; C, the bundle sizer spring, on a Massey Harris binder

adjustable by means of the tighteners, which allow the canvas to be slacked off at night when not in use. After being delivered over the seventh roller the grain reaches the deck.

This forms the binding table, on which the grain is formed into a sheaf and tied. It slopes down to one side to assist the action of the packers which sheaf the corn. The packers, usually three in number, are curved arms, each mounted at its centre on a crank on the packer shaft. This shaft is situated under the deck in a fore and aft position. It is driven at the rear end by the long elevator chain, which passes round the crank shaft and the elevator sprockets. The lower ends of the packers are hinged to a rod passing along the lower edge of the deck. Thus when

in motion the packers have a reciprocating action, and as they work up through the table in turn they gather the grain coming over the roller and pack it into sheaf form. This takes place in a space bounded on one side by the packers themselves, on the other side by the compressor, above by the breastplate, and below by the trip lever.

When the sheaf reaches its full size it presses down the trip lever and throws the binding mechanism into gear. The knotter shaft, which is placed above the lower edge

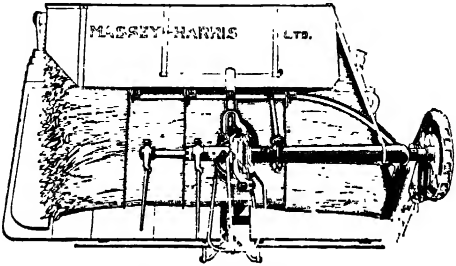


FIG 88. Binding deck adjusted for tall grain

of the binding table, distributes the drive to the various parts engaged in tying the sheaf. It is driven from the packer shaft, or an extension, through a shaft or chain, this drive operating only when the clutch controlling it is thrown in by the depressing of the trip lever by the sheaf. The end of the knotter shaft carries a wheel to which is attached a crank pin and connecting rod. This rod drives the needle shaft to which it is attached at its other end. The needle shaft thus makes a half revolution, when the knotter shaft makes a full turn.

The needle, through which the twine is threaded, lies below the deck while the sheaf is being formed, but when the binding mechanism is put in gear the needle rises from behind the sheaf and carries the twine round it. While the sheaf is being made the end of the twine is held by the knotter, so that the twine is lying under the grain.

Thus when the needle passes over the sheaf it completes the circle of twine, leaving the two ends ready for tying.

The knotting mechanism is situated at the lower end of the breastplate and comprises several members, which are actuated by gears or cams on the knotter shaft. The same parts are employed in practically all makes, but their form and relative positions differ somewhat. The end of the twine is held by a notched disc, called the "twine holder." Each time a sheaf is tied a fresh end has to be held by the disc. It is therefore moved round, notch by

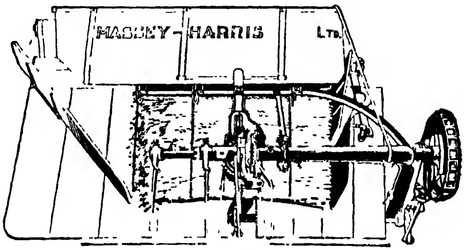


Fig. 89. Binding deck adjusted for short grain

notch, being actuated by a pawl carried on a rocker arm, which receives its motion from a cam on the knotter shaft disc.

The tying of the knot is performed by the knotter hook. This has two jaws, of which the upper is pivoted and fitted with a cam at its back end. The whole is carried at the lower end of an upright stem, at the top of which is a small bevel pinion. The two ends of twine to be tied are laid over the top jaw of the knotter, being led into position by the twine disc and the needle. As soon as the twine is in position the stem carrying the hook is rotated through a few gear teeth on the large disc coming into mesh with the small pinion at the top of the stem. As the stem moves round, carrying with it the knotter, the jaws open and grip the ends of the twine. This is effected by the cam on the end of the upper jaw coming in contact with a

raised projection above it. While the hook is turning the twine is cut off from the main length by the knife or billhook. This is usually mounted on the same rocker arm that operates the twine disc. By the action of another cam on the operating disc the rocker arm is moved in the reverse direction, drawing the billhook blade across the twine and severing it. The knot is completed by the loop being stripped off the jaws over the two ends of the twine. In some cases this is accomplished automatically when the sheaf is thrown out, while in others a special stripper is employed.

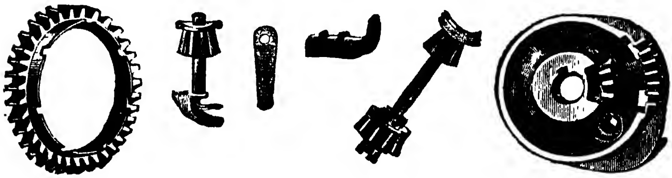


FIG 90. Knotter components as employed in the Massey-Harris machines. On the left is the twine holder and the knotter hook, while on the right is the cam and gear wheel

The sheaf is thrown out by three ejector arms mounted on the knotter shaft. As the shaft turns to effect the tying of the sheaf, the arms move over and inwards. Thus at the end of the tying operation they are in such a position at the back of the sheaf that on the completion of the revolution they force the sheaf out from under the breast-plate and eject it on to the ground.

The action of the compressor must also be noticed. Just before the sheaf is tied, the compressor arm, actuated by a connecting rod off the driving wheel of the knotter shaft, moves slightly inwards, thus further compressing the sheaf and allowing the knot to be firmly tied. To allow the sheaf to be ejected freely the compressor is then

pulled right down out of the way. At the same time the bottom boards at the edge of the deck are also dropped. In some machines the compressor only is employed, and combines as well the functions of the trip lever.

To ensure that the butts of the sheaves are squarely made, a device known as the buttor board is employed. This is a short reciprocating board placed at the forward

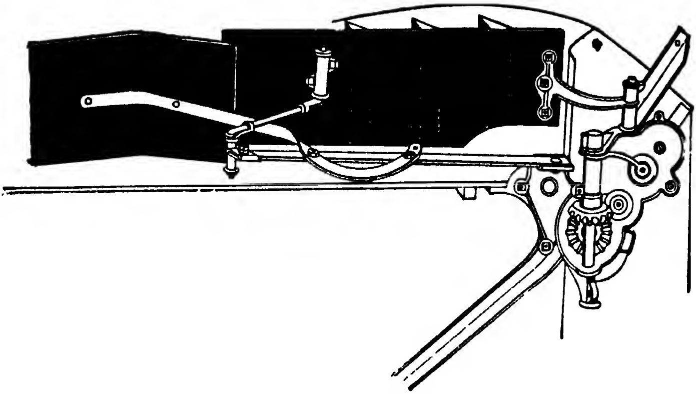


FIG. 91 The Massey-Harris buttor board

end of the deck, driven by a crank arm from the upper elevator roller. It is continuously in action and works up the corn into a level butt.

To enable the machine to tie the sheaf in the correct place, irrespective of the length of the grain, the binding table is so arranged that it can be slid backwards or forwards by means of a lever placed convenient to the operator's hand. This does not alter the position of the knotting mechanism.

The twine is carried in a can, which holds two balls, situated either at the front or the rear of the binder. The

end of the top ball must be neatly tied to the beginning of the lower ball, and the twine is led out from the can through a tension device, and passes via several eyes to the needle.

To thread the needle, the trip lever is depressed so as to allow the needle to be moved into a convenient position. The twine is then threaded through the eye, leaving a few inches over. The ejector arms are then turned through the remainder of the revolution, when the needle will automatically lay the loose end of the twine into the holder, and then recede, leaving the twine ready for tying. The waste twine projecting from the twine holder is cut off, and a trial knot tied, sufficient twine being held in the hand to form a loop.

Most of the parts of the reaper and binder are adjustable, more especially those belonging to the binder attachment. Correct adjustment is an essential condition for good work. As a rule any maladjustment, producing a badly tied sheaf, exhibits fairly characteristic symptoms, from which the trouble can be traced to its source. In dealing with binder troubles, therefore, as in the case of all machinery, it is necessary to bear in mind the function of each part when tracing the cause of any failure.

The tension of the trip lever is adjustable by means of what is sometimes known as the bundle sizer spring. This adjustment is the correct one to use when altering the size of the sheaf. Putting on more tension naturally increases the weight of the sheaf. The size of the sheaf can be altered by adjustment of the compressor and the trip lever.

Should the sheaves be thrown out with the band loose and the knot tied on only one end of the twine, the trouble may be due to the twine disc or the needle. Insufficient travel on the part of either of these will result in only one piece of the twine being gripped by the knotter hook. Slackness of the twine holder may allow the cord to be pulled out before the knot is tied and loose sheaves are thrown out.

Should anything happen which causes the binder clutch stop to be held out, the binding attachment will remain in

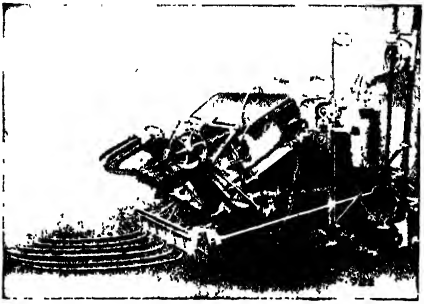


FIG. 92A
Large sheaf carrier

gear, with the result that a number of "baby bundles" will be made. A blunt billhook will allow the twine to pass uncut, with the effect of producing sheaves tied

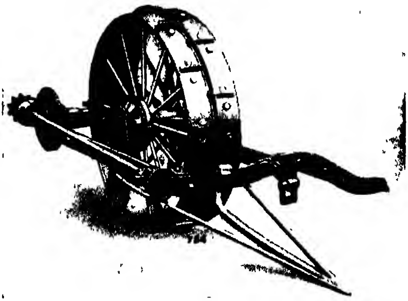


FIG. 92B
Opening out divider

together. Some of these symptoms may also be produced by the knotting mechanism being choked by fluff from the

twine. Hence it is important to use twine that does not fray. The commonest trouble is due to the twine breaking, and here, again, the necessity for using good twine is apparent.

The run of the cord from the box is controlled by various forms of tension devices. The spring of the tensioner should not be screwed down too tightly, otherwise unfair strain is imposed on the string and frequent breakages occur. Too little tension, however, will result in loosely tied sheaves.

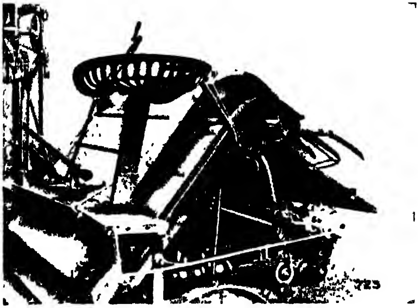


Fig. 92C

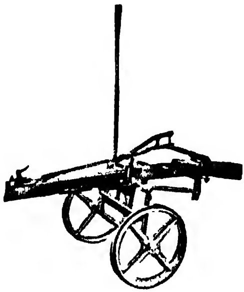


Fig. 92D

C, knotter control, and D pole carrier as employed on Harrison-MacGregor machine

Care should be taken to see that the various driving chains are maintained at the correct tension. Too slack a chain produces a snatchy drive, with the result that breakages may occur. On the other hand, a tight chain causes hard running and rapid wear. Lubrication of all moving parts is vitally important and must be attended to at least twice a day, and oftener where necessary. The chains need to be greased, as oil soon dries off.

The canvases must always run true on their frames. Should the frames get out of square the slats are soon torn off the canvases. Most elevator frames may be squared up by means of cross stays with threaded ends. The canvases must be slacked at night and at all times when not in use. The binder should be covered with a sail at

night to keep off the dew and prevent the formation of rust on any of the bright parts. Should the knotter hook become rusty it must be polished up with fine emery cloth, otherwise it cannot function properly. Damp has also a bad effect on the canvases, causing shrinkage.

Should the crop be very thick, and especially when tangled, difficulty may be experienced in getting it tied sufficiently quickly. In this case the outfit should be driven so that only a portion of the cutter bar is in action. This will of course relieve the binding table to the necessary extent.

In the field it is necessary to carry spare links for the driving chains, since it is fairly common for these to break, especially on bumpy ground. The correct speed for most machines is about three miles an hour. Jerky driving nearly always causes considerable damage to the machine. With a light tractor and a six foot binder about two acres per hour should be cut under favourable conditions. To tie an average crop of wheat, about one ball of twine per acre is required.

The sheaf carrier is an attachment designed to catch the sheaves as they are thrown out. It consists of a light steel cradle, which can be swung up at will to discharge the sheaf. The small type is designed to carry the sheaves at the corners only, but larger sizes can be used carrying enough sheaves to make a shock. The employment of this type saves labour in picking up the sheaves. They are, however, awkward on hilly ground.

An important device recently introduced by the International Harvester Company is the mechanical stooker. This trails behind the binder from which it receives the sheaves, which are thrown on to a forked arm. This lifts each sheaf and lays it at the rear of the machine on a platform. On this the stook is built up, lying on its side. When complete it is tied round with twine, and the platform then tilts and deposits the stook on the ground.

It is customary in most places to cut a path round a field of corn to allow the binder to enter. To obviate the

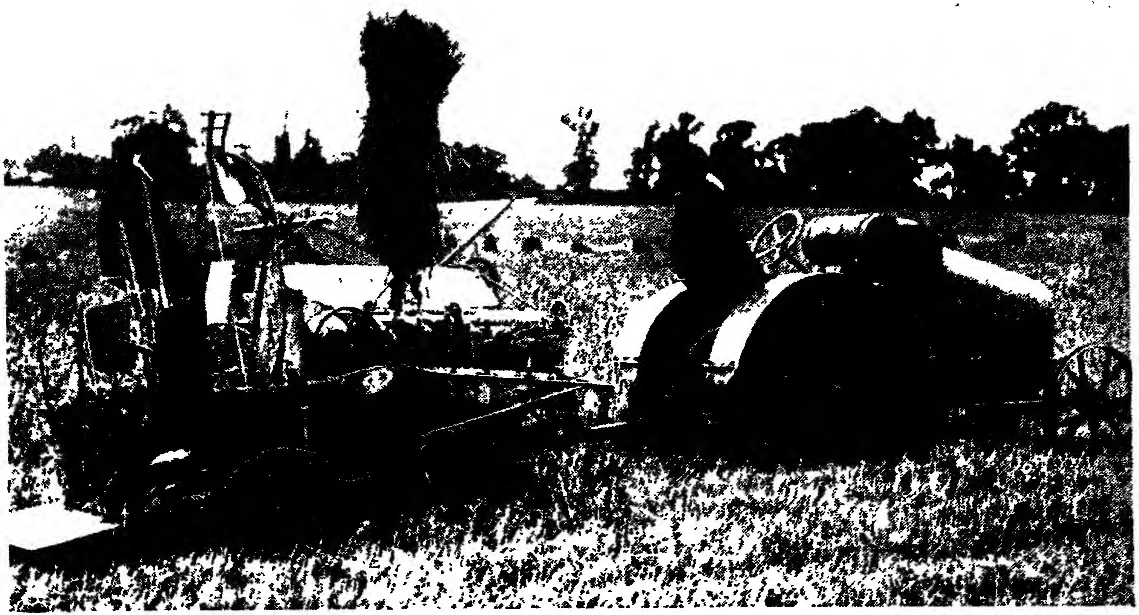


Fig. 93. Cutting, binding, and stooking with the International Harvester Company's stooking machine

necessity for this expense, an opening out divider has been designed by Messrs. Harrison, MacGregor. This is fitted on in front of the main wheel and parts the corn, so that the binder can be driven into a standing crop.

The same firm also market a knotter control device, designed to replace the small sheaf carrier. This consists of a clutch placed in the packer shaft, enabling it to be thrown out of gear when turning at the corners. While the clutch is out no sheaves are, of course, discharged.

The draft of a binder is comparatively heavy and very trying to horses. To overcome this difficulty the Walter A. Wood binders are fitted to order with a light air-cooled engine to drive the working parts. This is especially useful where horses are used, since they are relieved of all strain except that of hauling the weight of the binder and engine.

There is another advantage, however, in that a mechanically driven binder can operate on much softer ground than would be otherwise possible. As the loss of efficiency in picking up power from the ground through the land wheels is in the neighbourhood of fifty per cent, the force of this will be realized.

For tractor work developments will probably follow the lines of a driving shaft, transmitting power from the tractor engine to the binder.

CHAPTER XV

STATIONARY MOTORS FOR FARM WORK

A SMALL stationary internal combustion engine is a necessity on almost every farm for driving barn machinery, etc., and many very efficient models can be obtained at reasonable prices. The majority of present-day engines are designed to use petrol or paraffin

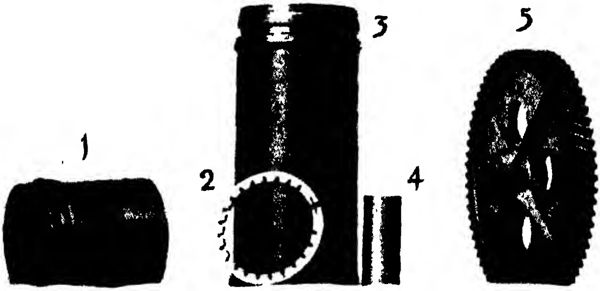


FIG. 91 Components of the Case 12-20 tractor engine
1, piston ; 2, piston ring ; 3, cylinder liner ; 4, piston pin ; and 5, timing gear

as fuel, and, owing to good design, the fuel consumption is quite a small item.

The main parts of an internal combustion engine consist of a cylinder, in which the explosion of the fuel takes place ; a piston sliding in the cylinder, on which the force of the explosion acts ; and a connecting rod by means of which the power imparted to the piston is transmitted to the crank shaft, which carries a belt pulley. From this pulley, power is given off to the driven machine, through a

belt which passes round the pulley. In addition to these fundamental parts a number of subsidiary parts are necessary, in order that the explosive charge may be admitted to the cylinder, fired, and the exhaust gases discharged. For this purpose valves and carburating and ignition appliances are required.

The sequence of actions which takes place in an engine of the four-stroke type is called the "four stroke" or "Otto cycle." Reference to the diagrams (p. 139) will show the action.

On the suction stroke the piston is moving downwards,

FIG. 95. Connecting rod from the Case 12-20

and in so doing it creates a partial vacuum in the space above the piston head, called the combustion chamber. As a result of this suction a quantity of the explosive mixture of fuel and air is drawn into the combustion chamber, through the inlet valve, which is open during the down stroke, the exhaust valve being closed. On the return upward stroke of the piston both valves are closed, and the charge is compressed in the combustion chamber. Both valves are still closed at the commencement of the firing stroke, when by some suitable means, usually an electric spark, the charge is fired. The explosion which takes place drives the piston downwards. This is the power stroke for the whole cycle. When the piston moves upwards again the exhaust valve is open, and the burnt gases are driven out. The cycle then recommences with the next stroke, which is an induction stroke.

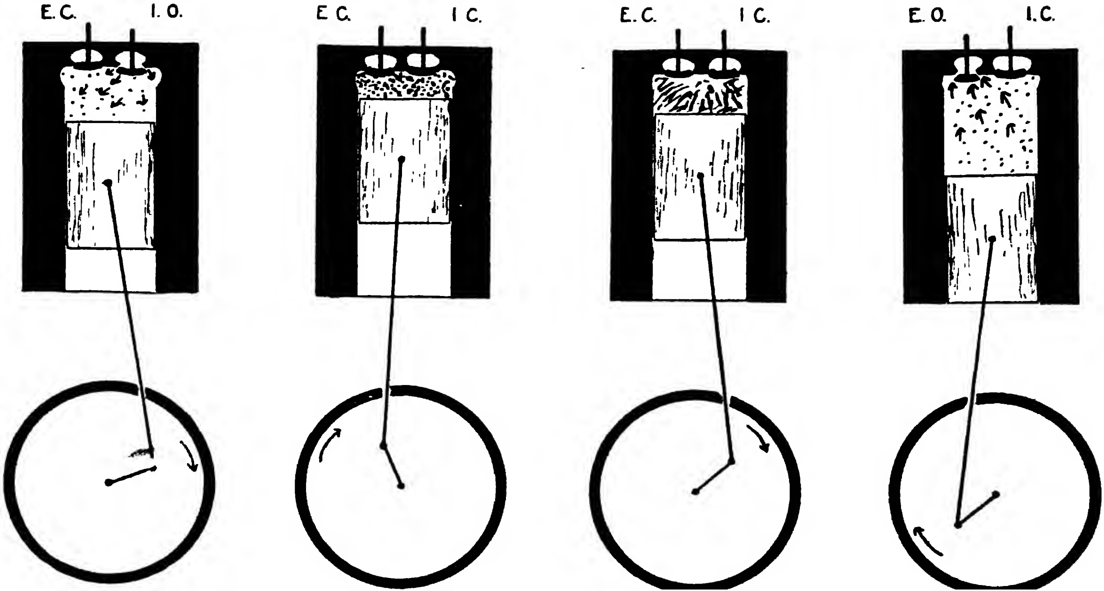


FIG. 96. Diagrams illustrating the Otto cycle
Left to right—induction, compression, firing and exhaust strokes

In the majority of four-stroke engines inlet and exhaust valves are situated in the main cylinder casting, but they may be in a detachable cylinder head (overhead valves). The valve itself is mushroom shaped and seats on to a circular opening, leading from the induction pipe in the case of the inlet, or into the exhaust tract in the case of the exhaust. The head of the valve is carried on a stem, which passes through a guide. To open the valve the stem is pushed through the guide a certain distance and the valve is thus lifted off its seating, opening an annular passage through which gas is admitted or exhausted, as the case may be. When closed, the valve is held down on its seat by means of a spring.

The methods of operating the valves vary according to their disposition. The standard method is that in which a cam shaft is driven by gears from the crank shaft. The cams lift tappet rods, which in turn raise the valves, for as long as the eccentric portion of the cam is against the tappet. Overhead valves are operated by rocker arms, actuated by push rods. In some cases inlet valves are not mechanically operated, but are lifted from the seat by the suction during the induction stroke.

In order that the fuel may be properly fired in the cylinder, it must be broken up into a fine vapour and mixed with the correct proportion of air in order to become explosive. This process is known as carburation and is performed in most engines by a carburettor, which on many farm engines is much simplified and becomes known as a mixing chamber. The general principle involved is the same, however, even though the design may vary greatly.

The fuel is contained in a tank, from which it is led by a pipe to the carburettor or mixing chamber. The air is drawn in through an opening into the induction tract as a result of the suction on the down stroke of the piston. In the path of the incoming air is placed a very fine spraying jet, into which the fuel is led. The air passing this jet assumes a high velocity, owing to the pipe being con-

stricted (the choke tube), and as a result it sucks out fuel from the spraying jet. As the fuel is drawn out it breaks up into a fine spray. It is obviously necessary that the fuel shall always be maintained at the correct level in the jet, and various methods are adopted to ensure this. In the standard carburettor a float controls the supply of fuel in the same manner that a ball cock controls water in a cistern. In some of the simple mixing chambers, however, the fuel level is simply maintained by a pump, or by the suction of the engine, any excess of fuel going back to the tank through an overflow pipe.

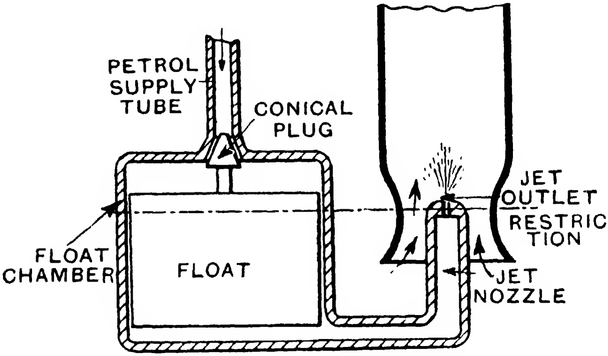


FIG. 97 Diagram of a simple carburettor

After leaving the jet the fuel, now vaporized and mixed with air, is drawn through a short induction tract to the inlet valve, the amount of mixture or gas passing to the cylinder being controlled by a butterfly valve called the throttle. This regulates the speed and power output of the engine. A wide open throttle, allowing the full amount of gas to pass, gives high speed and power. As it is necessary to vary the proportion of fuel to air, controls are usually provided for this purpose. The amount of fuel is generally regulated by a needle valve, which often acts in the jet itself. The amount of air taken in is adjusted by various types of regulators.

In cases where two fuels are used, e.g. petrol for starting and paraffin for ordinary running, the tank is usually divided and the fuel pipe provided with a two-way cock, so that either fuel may be passed at will.

The commonest fuels for farm engines are petrol and paraffin. Petrol is the lighter spirit, and good grades volatilize easily. Paraffin, however, is much heavier and will not vaporize at atmospheric temperatures. It is therefore necessary to apply heat to the mixing chamber to volatilize paraffin. Thus, it is usual for paraffin engines to be started from cold on petrol, and subsequently to be turned on to the standard fuel. Once the engine is running the heat generated by previous explosions is utilized to heat and vaporize the mixture.

In many paraffin engines water may be injected with the charge to prevent overheating. It is led through a valve to the cylinder from the water jacket and is controlled by a screw-down needle. The water is converted to steam and adds power to that developed by the charge of paraffin. It helps to keep the engine clean, in addition to preventing pre-ignition.

In most up-to-date farm engines the charge is fired by an electric spark generated by a magneto. For ordinary management of these engines it is not necessary for the operator to have an expert electrical knowledge. The care and attention required are confined to a few mechanical features of the magneto, and if any electrical trouble should occur the matter must be put into the hands of an expert.

The magneto may be one of several types, and we will deal first with the high tension (H.T.) type. In this machine two or three large horseshoe magnets are placed side by side, giving the magneto its characteristic appearance. The poles of these magnets are fitted with pieces of soft iron called pole pieces. Between these is placed the armature, which is cylindrical in shape, the pole pieces being hollowed out partially to surround the armature. The latter is mounted on a spindle carried usually on ball bearings at each end of the magneto frame. It consists of

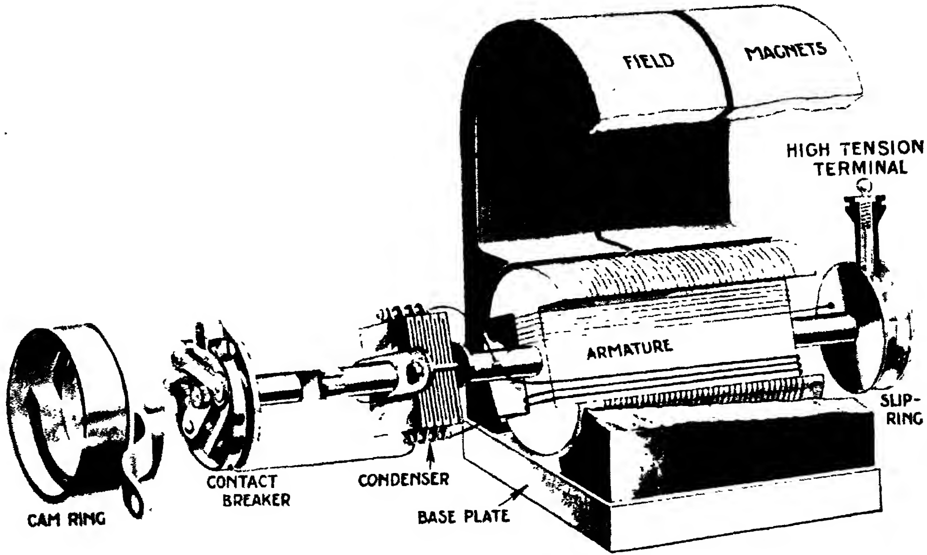


FIG. 98. The components of a high tension magneto.

an iron centre, round which are wound two coils of wire. One, the primary, comprises a few turns of thick wire; and the other, the secondary, many turns of fine wire. Both wires are covered with insulating material.

The act of moving a coil of wire in the neighbourhood of a magnet produces an electric current in the wire. This is intensified if an iron core is placed inside the coil.

Upon rotation of the armature shaft (it is driven by suitable means from the crank shaft) a low tension current is set up in the primary winding. Low tension (L.T.) means low voltage or low pressure. Now if the flow of L.T. current is suddenly broken in the primary winding, a H.T. current is set up or "induced" in the secondary winding. The necessary interruption of the L.T. current is effected by means of the contact breaker. This is mounted on the end of the armature shaft and can be seen by removing its cover.

The contact breaker is usually built up on a gun-metal base screwed to the armature shaft. On this round plate is a bell crank lever or rocker arm, the pivot of which turns in a fibre bush on the plate. The arm is normally held in position by a flat spring, which tends to force one end of the arm out towards the casing of the breaker. The other end of the lever carries a platinum contact point, which bears up against a similar point mounted on a block of insulating material. These two contact points are connected electrically to the primary coil of the armature, and when they are pressed together by the spring the primary current flows through them.

On the casing surrounding the breaker disc is placed a cam or raised projection. The outer end of the rocker arm carries a rounded block of fibre. As the shaft revolves, carrying round the breaker plate, this fibre block meets the cam and is forced inwards. This causes the other end of the arm to move and separates the contacts. When the cam is passed the spring forces the contacts to close again.

When the contacts are opened the primary circuit is

broken, and the H.T. current is set up in the secondary winding.

To prevent the formation of a spark at the platinum points when they separate, a device known as a condenser is used. This is placed on the armature spindle just behind the contact breaker. Finding its path through the contacts broken, the L.T. current rushes into the condenser, which acts like a buffer and forces the current back into the primary winding. This action is important for electrical reasons, but the condenser is not likely to concern the operator of the engine.

The secondary winding is connected at one end to the

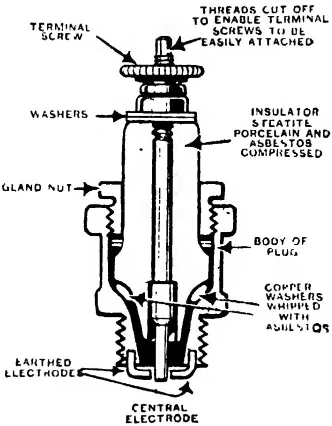


FIG. 99. Sectional diagram of a sparking plug

primary and at the other to a brass slip ring, which is carried on the driving end of the armature spindle. From the slip ring the current is collected by means of a block or pencil of carbon which bears on it, and is called a brush. This is pressed down lightly by a spring. From the carbon brush the current is taken by a conductor to the terminal, to which is attached the flexible lead going to the spark plug terminal.

In case anything should prevent the normal passage of the H.T. current it is necessary to provide a safe alternative outlet for it. This takes the form of a safety spark gap situated at a convenient point of the H.T. conductor. It simply consists of two metal points forming a spark gap across which the current will jump if anything stops its usual path. One of the points is connected to earth.

The spark plug is screwed into the cylinder so that its points or electrodes are in the combustion space. The H.T. current passes down the central electrode and jumps from point to point, creating a hot spark at the end of the compression stroke. The current then completes its circuit by passing through the metal of the engine back to the magneto. This is called an "earth" return.

A large number of magnetos on farm engines are of the oscillating type. In these machines the armature shaft carries a trigger arm at the driving end and is held in a certain position by a strong spring. Through the medium of a cam or similar device the trigger is pulled out of position a short distance and then allowed to fly back with the force of the spring. Thus by this movement the current is generated. Owing to the fact that the motion imparted to the armature is due to the spring, this type of magneto always gives a spark of the same intensity, irrespective of the speed of the motor. In the case of the rotating armature magneto the strength of spark is dependent on the speed of rotation and hence on the speed of the engine.

Low tension magnetos, which are common on farm engines, are usually of the oscillating type. In these machines the armature has no secondary winding, and the L.T. current generated is led to an igniter plug situated in the combustion chamber This plug has two contacts, one of which is hinged, the two being normally held together by a spring. At the moment when the spark is due, however, the contacts are forced open by a push rod operated from the crank shaft and the current is forced to jump the gap thus created.

Since there is a limit to the temperature the metal of the engine and the lubricating oil can withstand, it is necessary to dissipate some of the heat. Most farm engines are water cooled.

The cylinder is provided with a water jacket, which allows the cooling water to flow round the cylinder and adjacent parts and keep the temperature down. The water jacket is connected with some form of container, either a tank or hopper. The amount of water necessary depends on the size of the engine and its fuel. Paraffin

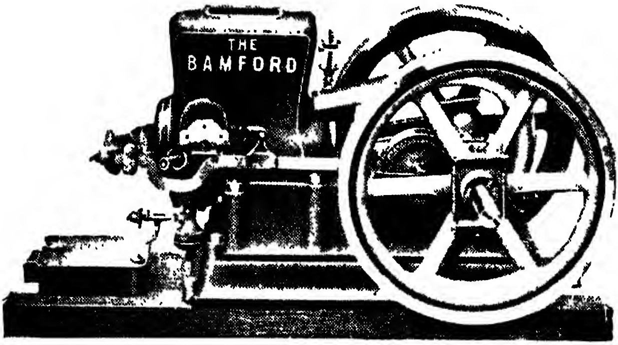


FIG. 100. A horizontal hopper-cooled four-stroke engine

engines must run a good deal hotter than petrol, and a small hopper is usually found on these. A tank or a hopper with a cooling screen is generally employed on petrol engines. The water circulates through the tank and jacket by reason of the fact that hot water tends to rise. Thus the water heated round the cylinder rises into the top of the tank and is replaced by cooler water from the bottom of the tank. This is the thermo-siphon system. At the tank or cooling screen the water gives up some of its heat to the air. Means are provided for draining the water jacket, and it is extremely important always to do this when there is any danger of frost. If water

freezes in the jacket the cylinder will almost certainly be cracked and considerable expense incurred.

A few air-cooled engines are on the market for farm

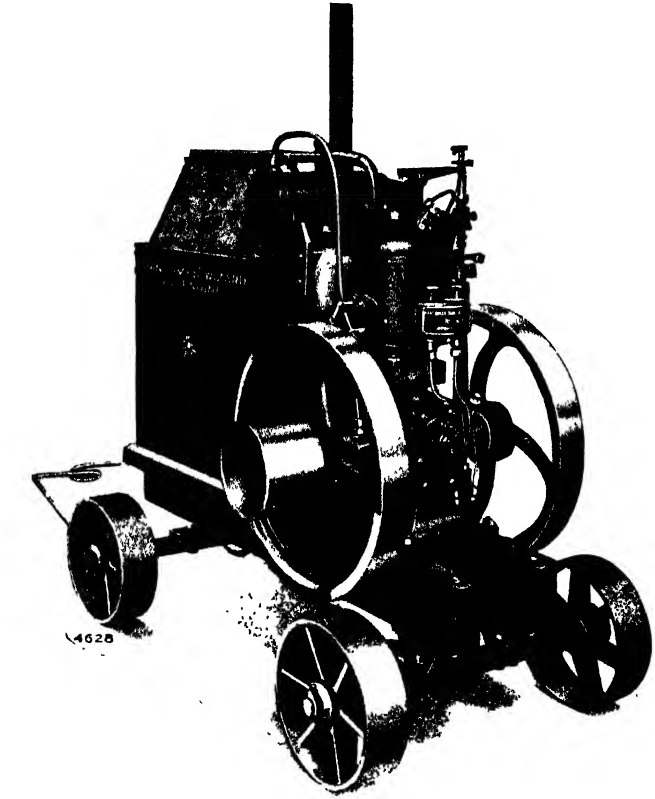


FIG. 101. Ransome's Wizard oil engine

purposes. These require rather more careful attention than the water-cooled, but suffer no damage from frost, as they do not carry water.

Lubrication is one of the most important points in the

management of any machinery, and especially internal combustion engines.

In the cylinder we have a piston continuously moving to and fro at a great speed and that at a very high temperature. If lubrication fails the metal will quickly get overheated, expand, and the piston will "seize up" and become immovable. The bearings of the crank shaft are working under great stresses, and lubrication is similarly vital to them. Such bearings are lined with anti-friction metal. If they suffer from lack of oil, the metal, on reaching a certain temperature, melts. This protects the journal, but renders the engine unusable till the bearing is re-metalled.

Various systems of lubrication are adopted, according to the engine design. In vertical engines the lubrication is frequently by "splash." The crank chamber contains a quantity of oil into which dips the connecting rod. In so doing it throws up oil which lubricates the cylinder walls, gudgeon pin, and big end bearings. The main bearings may be oiled by sight feed cups, grease cups, or oil forced by pump from the crank case sump.

In horizontal engines the splash system is not usually applied. Sight feed oil cups are frequently used for cylinder lubrication as well as for main bearings. The big end bearing may be lubricated from the main bearing supply through oilways drilled in the shaft, or grease cups are sometimes employed to give a direct supply to the bearing. This is not a good method as the supply is uneven and it is necessary to stop the engine from time to time to screw down the grease cap. All exposed working parts need attention with the operator's oil can, a few drops being given at intervals.

The sight feed oilers generally have a central needle passing down to the outlet pipe and seating into a conical opening. The needle can be raised or lowered to open or close the valve.

Some form of speed regulating device is always necessary on these engines. The governor commonly acts by centri-

fugal force, and limits the speed of the engine to the point considered most satisfactory by the makers. There are several different types employed, but the throttling governor is now most usually found.

A pair of weights are pivoted to a collar which turns with a rotating spindle, on any convenient part of the engine, and is free to slide along it. As the speed of the engine increases the weights fly out and draw the collar

FIG. 102. A sheep shearing attachment for the Lister engines

along the spindle. This motion is transmitted by a series of rods and levers to the throttle valve, which it closes if the speed exceeds the normal. On the speed falling again the governor control opens the throttle. The governor acts against the force of a spring, and by altering the strength of the spring the speed to which the governor limits the engine can be raised or lowered. Ordinarily, the maker's setting should not be departed from, as racing the engine is very bad practice.

In some cases governors of the hit and miss type are found. These interrupt the ignition at a predetermined speed and cause the engine to miss firing the charge. This method is wasteful of fuel. Other types of hit and miss governor stop the inlet valve opening, therefore preventing the admission of the charge till the speed is normal. The throttling type, however, is widely adopted and is most satisfactory, giving economical and even running.

TWO-STROKE ENGINES

So far only engines of the four-cycle type have been dealt with, as these are by far the most common type for farm use. The two-stroke type, however, has many advantages and is being developed for running on paraffin. As there is a power stroke for every revolution a more steady pull is given by each cylinder, while a further benefit is the simplification of the engine by eliminating valves.

In a two-stroke the fuel mixing chamber communicates with the crank case, which is gas tight On an up stroke of the piston, gas is drawn into the crank case, and on the down stroke it is partially compressed. On the piston reaching a certain point it opens an exhaust port in the wall of the cylinder, through which the exhaust gases discharge. Immediately afterwards a transfer port is opened on the opposite side of the cylinder. This transfer port communicates with the crank case, and the partially compressed gas rushes through the passage into the cylinder. A special deflector cast on the top of the piston prevents the gas going out through the exhaust port by throwing it upwards.

The entry of the fresh gas helps to force the exhaust out,. and "scavenges" the cylinder. As a matter of fact, a certain amount of the exhaust gas remains behind in even the best designed two-strokes and so dilutes the incoming gas.

On the up stroke of the piston, the fresh charge is finally

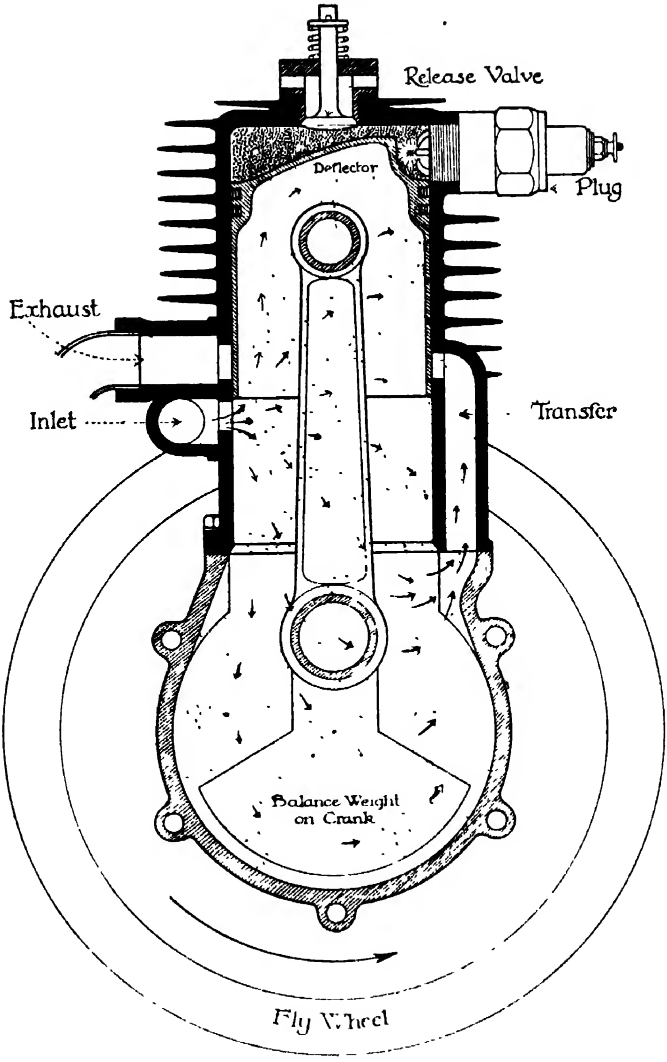


FIG. 103. Diagram of a two-stroke engine. Firing point.

compressed and fired, while in the meantime the crank case has again become filled with mixture.

Several high compression two-strokes are now on the market, one of which is the Wizard, made by Messrs. Ransomes, Sims & Jefferies, of Ipswich. In this engine only air is compressed in the crank case. The fuel (paraffin) is admitted into a small spraying cup in the cylinder head when the piston is at the bottom of its stroke. On the up stroke the compression rises to about 450 lbs. per square inch (over three times as great as in an ordinary engine). Air is forced into the cup and causes the lighter parts of the paraffin to ignite. As a result, the bulk of the fuel is forced out into the combustion chamber and ignites spontaneously under the great pressure, without any electric spark or other device. The engine is thus greatly simplified and can, moreover, be started from cold on paraffin. All the features of the engine make for reliability, and this type should have a great future for farm work.

CARE AND OPERATION

With any make of engine it is important always to follow the maker's instructions regarding the operation of the engine, as each make varies in detail. The following notes, however, apply practically to any modern engine.

Before starting see that the water cooling system, fuel tanks, and lubricating systems are full, and ascertain that the ignition system is in order and all connexions perfect.

If all is in order, prime the engine with petrol (according to type), set carburettor for giving a rich mixture, and crank the engine with compression relief tap open. Never place thumb round starting handle. Always have thumb and fingers all on one side: if the engine backfires you are then safe. If it backfires and you have your thumb round the handle you will almost certainly have your wrist broken.

When the engine starts to fire, close the compression tap and set the carburettor for normal running.

While running look over the engine from time to time

and see that all is in order. Never neglect lubrication. Hot main bearings, detected by feeling, indicate lack of lubrication and should at once be attended to. Always use a good grade of oil: one will usually be recommended by the makers. A thinner oil is necessary in winter than in summer. Always see that in cold weather the oil is thin enough to flow through the oil cups and pipes. Warm it if necessary. With grease cups, keep the grease free from any dirt or grit, which will cause great damage if forced into the bearings. Give the grease cups several turns down till the grease is seen exuding from the ends of the bearing. Always wipe off excess oil and keep the engine clean.

It is most important to avoid overloading. This is indicated when the engine labours (speed reduced much below normal and pounding knocks heard), together with overheating.

Watch the exhaust; it should be clean. Black smoke shows too rich a mixture; give less fuel in proportion to air. Blue smoke indicates over-lubrication of the cylinder.

When knocking occurs on full load with a paraffin engine the water drip, if provided, may be turned on. Do this cautiously till the knocking ceases. If too much water is given it may cause misfiring or stoppage of the engine. Always turn off the water drip some time before stopping, otherwise water may be left in the cylinder and cause difficulty in starting next time. Never turn on water till the engine is really hot.

Do not forget to drain the water jacket every night in frosty weather.

SOME COMMON TROUBLES AND THEIR CAUSES

Fault	*Cause*	*Remedy*
FAILURE TO START	No fuel in tank	Fill.
	No fuel in mixing chamber due to choked pipe or pump not acting	Clean pipe or remedy pump trouble.

SOME COMMON TROUBLES AND THEIR CAUSES—*Contd.*

Fault	*Cause*	*Remedy*
FAILURE TO START—*Contd.*	Wrong mixture. (*a*) Too rich, due to over-priming or stopping engine on full throttle, (*b*) Too lean	(*a*) Shut off fuel and crank engine with air inlet and compression tap open ; (*b*) Prime, and adjust fuel needle. Close air inlet.
	Ignition circuit not completed. Terminal off, or short circuit due to a worn lead or terminal touching engine frame	Examine full circuit and remedy if necessary.
	Water in fuel	Drain tank and refill through strainer.
	Defective plug. Points too close or too wide or water on points, due to stopping without turning off water injection	Examine and correct points to $\frac{1}{32}''$ gap. Dry plug by heating.
	Wrong fuel. Attempting to start from cold on paraffin	——
	Air leak in induction pipe, resulting in excessively lean mixture. Detected by hissing noise	Remake defective joint.
	No compression. Valve stuck open	Free valve. If due to bent stem or weak spring, replace.
	Magneto trouble. On oscillating type push rod or picker may be out of action	Examine carefully when turning engine over slowly.
	H.T. type contact breaker points stuck open due to swollen fibre bearing ; occurs through damp	Carefully ease bearing, by reamering out with a fine point.
	Magneto timed wrong, through operating device shifting position	Check timing and reset if necessary. Points, should break 5° before end of compression stroke.

SOME COMMON TROUBLES AND THEIR CAUSES—*Contd.*

Fault	*Cause*	*Remedy*
ENGINE STARTS BUT REFUSES TO CONTINUE RUNNING—		
Dense black exhaust	Too rich a mixture ..	Give full air and adjust fuel valve.
Clean exhaust	Lack of fuel, engine only firing on priming	Look for partly choked fuel pipe or defective fuel pump.
ENGINE RUNS IRREGULARLY	Dirty plug	Examine and clean.
	Weak spring on oscillating magneto	Tighten or renew.
Smoky exhaust	Fuel mixture too rich	See above.
Blow backs through mixing chamber	Water in fuel. Excessive water injection. Fuel mixture too lean	Adjust carburettor.
Back fires ..	Sticking exhaust valve. Faulty ignition leads causing occasional shorts. Cracked sparking plug. Governor out of order. Pitted contact breaker points	Remedy valve, ignition, or governor trouble. Replace plug. Carefully file breaker points.
ENGINE STOPS WHILE RUNNING	Any of the foregoing causes may be sufficient ultimately to stop the engine	—
	Overheated and piston seized up	Examine cooling system. If short of water and boiling, allow to cool down. Flood cylinder with lubricant and attempt to free by gently rocking flywheel backwards and forwards. Examine lubricating system to see if cylinder underlubricated.
	No fuel	Fill tank.

SOME COMMON TROUBLES AND THEIR CAUSES—*Contd.*

Fault	*Cause*	*Remedy*
LOSS OF POWER	Defective scavenging ..	Exhaust valve closing too early. Check timing.
	Worn piston rings ..	Renew.
	Valves not seating well	Grind in or strengthen springs.
	Valve stems warped ..	Renew.
	Loose plug	Tighten.
	Cylinder head or valve cap gasket leaking	Remake joint, renewing gasket if necessary.
Overheating..	Inefficient cooling Inefficient lubrication ..	Keep cooling hopper filled and lubricate correctly (especially important on air-cooled engines).
	Spark too late	Adjust timing.
	Engine overloaded ..	Reduce load.
ENGINE KNOCKS—		
Pounding ..	Carbon deposit on cylinder head and piston (pre-ignition)	Take engine down and clean.
	Overheating due to an overload or retarded spark	Reduce load and advance spark.
Pinking ..	Spark advanced too far	Retard slightly.
Metallic knock	Engine overloaded or big end bearing worn	Reduce load. Take up bearing
Rattling knock	Piston slap due to loose piston	New rings. Usually necessary to renew piston and possibly cylinder

CHAPTER XVI

BARN MACHINERY

THE CHAFF CUTTER

THE great majority of up-to-date cutters follow the same general design and differ only in detail and in attachments, which are fitted to some of the larger machines for sifting and bagging, etc.

The cutting parts and driving gears are arranged on a rectangular framework on the stand. The feed trough usually runs at right angles to the frame and may or may not be fitted with a conveyor. The hay or straw is fed along the trough to the throat, where it is gripped between two toothed rollers and passed to the knife. The knives are mounted on the flywheel and are two or three in number. The cut takes place between the moving knife and the shear plate, on to which the hay is fed by the rollers. Adjustment of the length of cut is made by altering the speed at which the conveyor and rollers run. When the hay is fed in faster, the knife speed remaining constant, the length of cut is increased, and vice versa. The upper roller is constructed so as to be floating, except in some of the smaller machines, so as to accommodate varying quantities of fodder. It is held down under pressure from either a balance weight or a spring.

The drive by belt is usually taken by a pulley on the main shaft, which carries the flywheel. From this shaft the drive for the rollers and conveyor is taken through bevel gears, controlled by dog clutches, which provide forward, neutral, and reverse positions. The clutch sleeve is connected up to a safety lever in front of the throat.

Should the throat become choked, reversal of the drive will enable the rolls to clear themselves. To give the varying speeds for altering the length of cut, the drive for the rollers is taken to a countershaft which carries pinions of

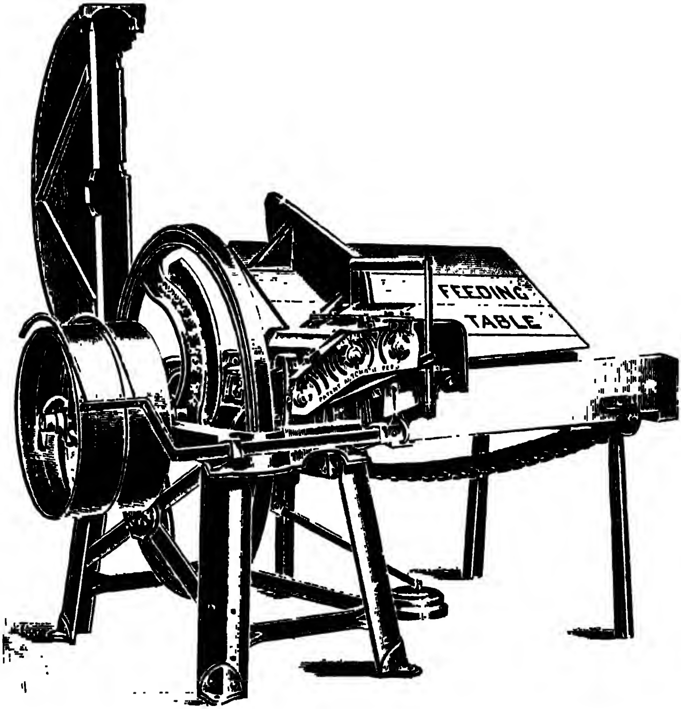


FIG. 105 A power chaff cutter with fast and loose pulleys

different sizes. A sleeve on the first shaft carries corresponding pinions, and any combination may be made to give different gear ratios. The drive to the conveyor and rollers is transmitted from the countershaft through spur gears to the driving shafts, which lie parallel to it. The upper roller driving shaft embodies universal joints to allow of the necessary up and down movement.

On some of the larger machines self-feeders are employed. These generally embody some form of reciprocating toothed rack working over the top of the feed trough, which drives the hay in to the throat. Sifting and bagging apparatus can also be obtained for a number of makes, the

TABLE 14

Knives	Width of mouth	Power B.H.P.	Speed	Capacity per hour in $\frac{3}{8}''$ chaff
	inches			cwts.
2	$9\frac{1}{4}$	$1\frac{1}{4}$	120	8
2	10	$2\frac{1}{2}$	200	18
2	$11\frac{1}{4}$	3	220	22
3	$11\frac{1}{4}$	$3\frac{1}{2}$	220	27
2	12	$3\frac{1}{2}$	220	24
3	12	4	220	32

dust also being extracted. These outfits are frequently fairly expensive and are more adapted to farms where feeding is carried out on specialized lines.

The maker's ratings for the type of machine illustrated (Bentall's) are given in Table 14.

ROOT CUTTERS

A wide range of machines for cutting, pulping, or shredding roots for stock feeding are obtainable for use in the barn and in the field. These are all simple in construction and need little description.

For work in the barn, the combined cleaner and cutter is a good type. This machine employs a rotating cage with spiral bars for the cleaning operation. The cage is driven round by a small pinion meshing with a gear ring on the outside of the cage. The slope of the cage towards

the cutter can be altered by means of a hand wheel at the upper end, so as to pass the roots through at a varying

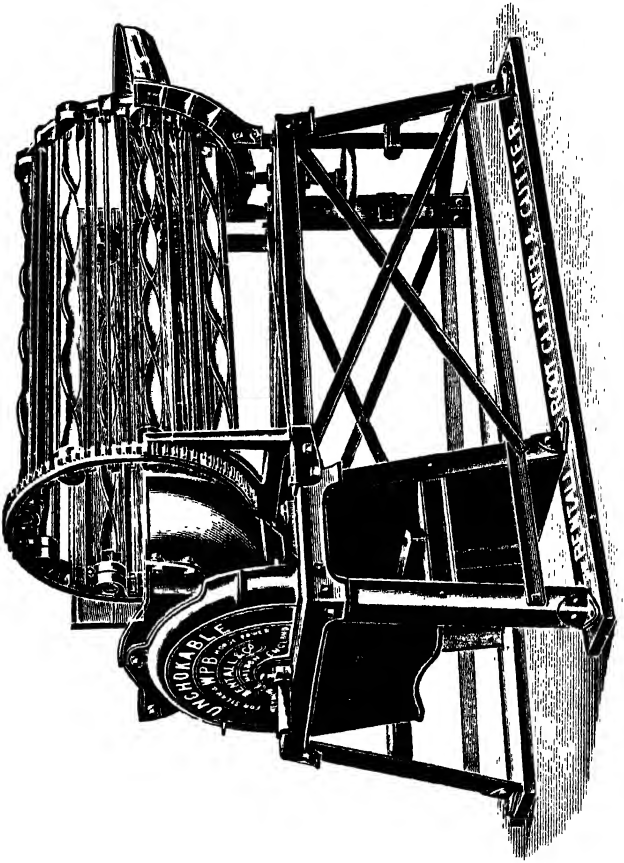


Fig. 106. Power driven root cleaning and cutting machine

speed. The roots are fed into a hopper at the top, and, as they pass through, the dirt is scraped from them. At the lower end they fall into the cutter.

This consists of a hopper, one side of which is formed by the cutting wheel. This is built of a solid plate, in which there are a number of small openings, each surrounded by a sharp-edged lip facing in the direction of rotation. The roots are forced against the wheel by a worm or other device in the bottom of the hopper, and small pieces are gouged from them by the cutting lips. These pieces pass through the corresponding holes in the wheel and are delivered on the far side. A wide range of knives or cutters can be obtained to suit individual requirements.

A different type of cutter generally employed for cutting turnips, without a cleaning apparatus, has a notched barrel working in the hopper. The notches are sharp-edged and cut the roots into slices of rectangular section. Here again slices of different sizes can be cut by employing various types of barrel.

One of the most recent developments in this class of machinery is the construction of motor cutters in which a small engine is built in on the frame of a portable cutter. This is intended for use in the sheepfold and elsewhere out of doors. This is a very useful arrangement, since it enables the shepherd to cut a considerable quantity of turnips, single-handed, in a short time. An air-cooled engine is usually fitted to eliminate any trouble from frost.

Another useful device is a cart fitted with a root cutter driven from the wheels. This will deliver the load, cut into fingers, on to the land or into a hopper on the cart. This is suitable for use where cut turnips are fed to sheep, etc., on grass land.

The portable root cutter can also be used, if required, for cutting roots at the clamp. The pulp can then be delivered on to the mixing floor direct, when required for feeding in the stalls. A number of these machines are self-propelling.

CRUSHING AND GRINDING MILLS

Amongst the barn equipment, machinery for grinding and crushing corn is usually needed, and it is often

advantageous to have one mill capable of doing both the jobs.

Crushing is done by means of two rollers, so adjusted that corn passed between them is crushed to the desired

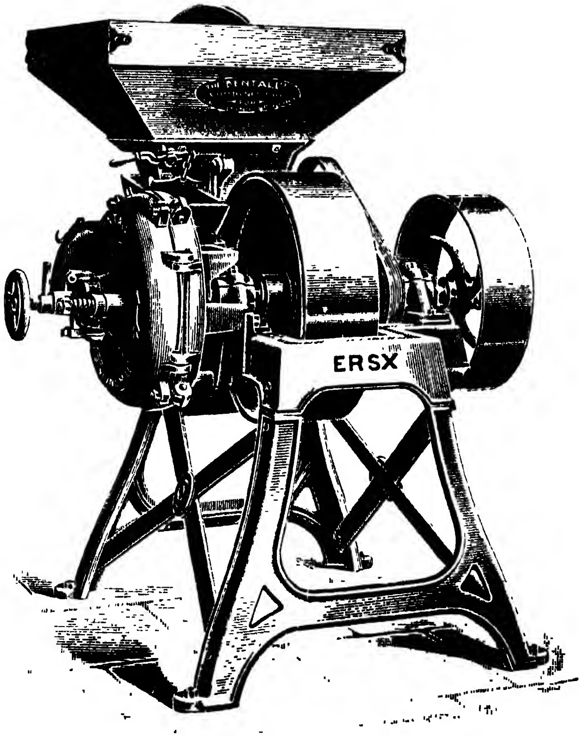


FIG. 107. A typical combined crushing and grinding mill

extent. Grinding is effected by passing the grain between two ribbed plates called "buhrs," one of which rotates, while the other is stationary. The corn can be ground to practically any degree of fineness.

In a combined mill, the working parts are carried on a strongly built stand, the wooden hopper at the top being divided into two parts. Dealing first with the apparatus for crushing, we find that a fluted roller driven by a small belt from the main shaft draws corn from the bottom of the hopper through a variable opening, which can be adjusted by a slide to any position. The fluted feed roller is situated immediately over the crushing rollers. Of these, one is carried in fixed bearings lined with anti-friction metal. The spindle carrying the driving pulley at one end, and the fixed roller, extends at the other end to carry one of the grinding plates. The second crushing roll is carried in sliding bearings, which are controlled by a hand wheel operating through a yoke. In some cases this roller is free, while in others the two are geared together when in action. By screwing up the hand wheel, the second roll may be forced closer to the first. The pressure put on by the hand wheel is transmitted to the roller through the medium of strong spiral springs. Thus in the event of a stone getting between the rollers, the latter can open so as to pass the stone through and so avoid damage. The corn, after passing through the rollers, goes down a delivery chute to the floor.

For grinding, the corn passes out of the other side of the hopper over a small oscillating screen, which separates any large pieces of foreign matter. It is led through the centre of the inner buhr, which is fixed, and becomes distributed between the two plates. The outer buhr usually slides upon the main shaft, but is driven round by it. Some pressure is maintained on the outer buhr by a spiral spring which surrounds the shaft and tends to force the plate outwards. Thus, when the grinding section is not in action, the buhrs are separated from one another. To put the grinding plates to work, pressure is applied to the outer plate by means of a hand wheel, till the two just touch. The hand wheel is then slacked off slightly and locked in position. Grinding should never be done with the plates actually touching. The buhrs may be of chill cast iron

or gritstone, and they usually have the grooves cut on both faces so as to be reversible.

It is possible in most cases to perform both operations at the same time if sufficient power is available.

The capacity and power required for various sizes of mill are rated for the Bentall machines as in Table 15.

TABLE 15

Size of large roller	Size of small roller	Diameter of grinding plates	Speed R.P.M.	Power to grind or crush separately B.H.P.	Approximate output in pounds per hour	
					Grind to Meal (Metal Plates)	Crush Oats
in. in.	in. in.					
18 × 4	12 × 4	8	450	$2\frac{1}{2}$–3	100–250	1330
18 × 4	12 × 4	9	450	3–4	160–450	1330
18 × 4	12 × 4	$10\frac{1}{2}$	450	$3\frac{1}{2}$–$4\frac{1}{2}$	200–580	1330
25 × 5	12 × 5	13	400	6–7	400–800	2000
25 × 8	12 × 8	15	400	8–9	550–950	2000

CAKE BREAKERS

These mills need to be of considerable strength, since some of the harder oil cakes require a good deal of power for breaking. The cake, placed in a hopper, is caught between two toothed rollers below the hopper and broken into pieces, the size of which depends on the closeness of adjustment of the rollers. In some cases a second pair of rollers is situated below the first pair, further to reduce the cake if required. The broken cake is delivered over a screen, which separates the dust or meal and allows it to fall into a second receiving box. The drive to the rollers is geared down considerably from the pulley or hand wheel in order to give the necessary power for breaking.

ARRANGEMENT OF BARN MACHINERY

This is a matter which should receive a great deal of careful thought when laying out, since correct arrange-

ment tends to reduce labour costs to a minimum. Each individual case naturally requires different treatment, but certain general principles apply in nearly all cases.

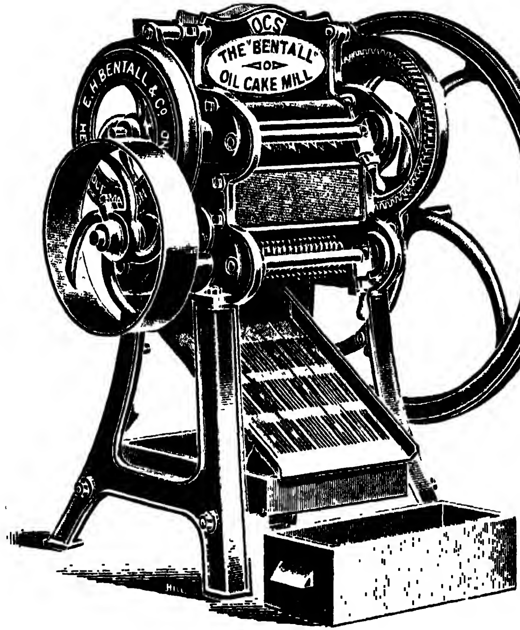


FIG. 108 A cake breaker

If the prime mover is an internal combustion engine, it should be accommodated in a shed adjoining the barn, with an opening in the dividing wall to allow the driving belt to pass through. Inside the barn a countershaft will have to be put up if a number of machines are to be driven. The machines should be so arranged that all can be driven from the one shaft, thus cutting down expense for

shafting, etc. The countershaft is usually best accommodated in the angle of the wall and the ceiling.

Some of the machines will be situated on the ground floor and some upstairs. The latter will generally include the chaff cutter, the cake breaker, and the grinding and crushing mill. On the ground floor will be the root cleaner and cutter. It is necessary to arrange these machines so that they will deliver their products into the place where they are to be used. The root cutter will therefore need to be positioned close to the mixing floor. The mill and

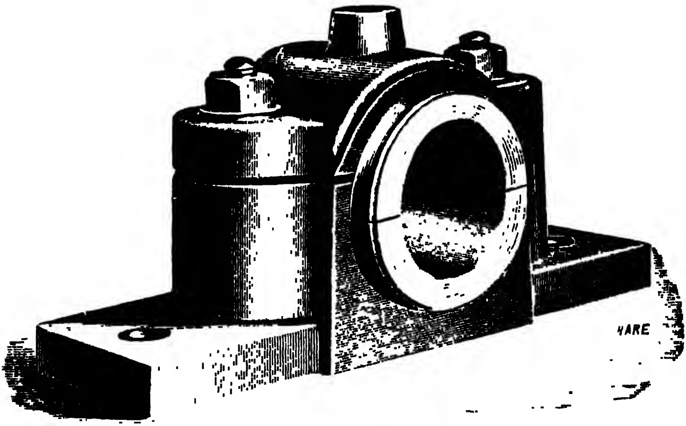


Fig. 109. A useful type of plummer block for barn shafting

cake breaker must be situated close above the storage bins, so that the meal and cake can be discharged down shutes directly into the bins without handling. Similarly the chaff cutter should discharge down a chute, which can be directed on to the mixing floor, or into barrows or sacks if the chaff has to be carried away to other feeding stalls. In some cases it may be preferable to situate the chaff cutter on the ground floor. With regard to this machine, and also the root cutter, care should be taken to set them so that the fodder and roots brought in can be easily off-loaded close to the machine, as otherwise much hand

labour may be wasted in bringing the hay and roots to the machines.

The necessary shafting is supported on brackets or hangers attached to the wall or the roof. The size of shafting and other particulars can be obtained from the tables given in the Appendix. Each machine needs a driving pulley on the countershaft, while a driven pulley to take the engine belt is also required. It will be necessary to calculate the sizes of pulley required by the formula also given in the Appendix.

The countershaft should run at a fairly slow speed; about 250 r.p.m. is generally satisfactory. Working from this speed, the necessary diameters for the various pulleys can be worked out. For driving, balata belting will be found very satisfactory and cheaper than leather. When the machines are in their correct positions, the belt for each

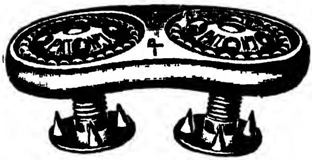


FIG. 110 Jackson's patent belt fastener

should be cut off the correct length and the ends squarely butted together. They are secured by one of the patent belt fasteners. For keeping the belts in good order, one of the standard proprietary belt dressings should be used. Most farm hands are too fond of putting on messy preparations of their own making, which often ruin a good belt.

When a belt is in proper condition it should take its full load without being unduly tight. A tight belt invariably means hard running, hot bearings, and rapid destruction of the belt. Whenever possible, where a belt is running in a nearly horizontal position, the under side should be the driving side, as this secures the largest arc of contact, and prevents slippage. Belt slip usually amounts to one or two per cent, but should not exceed this.

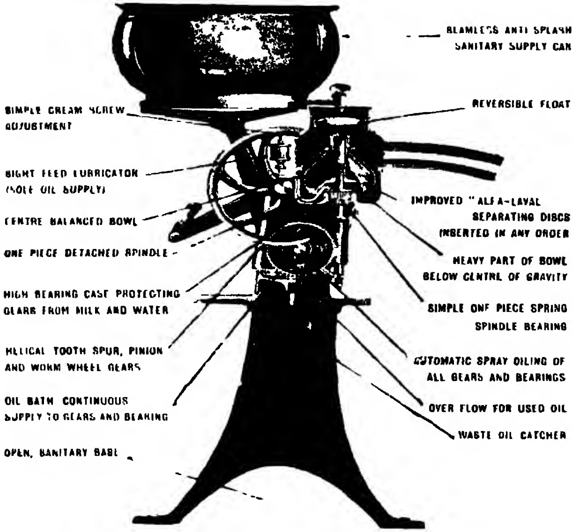


FIG. 111. Diagram illustrating the principal components of the Alfa-Laval machine.

CHAPTER XVII

THE CREAM SEPARATOR

THE efficient separation of the butter fat from whole milk is an important matter in the dairy, since the total quantity of fat in the milk is seldom above four per cent, so that even a small percentage loss of cream is a serious one. Separation is effected by taking advantage of the difference in the specific gravity of the fat and the rest of the milk, the fat being the lighter. The old method of separation was to set the milk in shallow pans and allow the cream to rise, when it was skimmed off by hand. By this method the percentage loss is high and the process a slow one.

A good mechanical separator does the operation very rapidly with a loss of less than two per cent of the cream, by taking advantage of the same principle, in combination with centrifugal action.

The sectional view of an Alfa-Laval machine shows the design of a standard type. The whole milk is placed in a large container at the top, from which it is allowed to flow into the machine through a float controlled valve. Passing straight up through the centre of the machine is the spindle, which is driven at a speed of over 5,000 r.p.m. through gearing from a pulley or hand crank.

Resting on the spindle, and driven by it, is the bowl, which contains the actual separating parts. The bowl has a conical, screw-on top, the joint being made tight by means of a rubber ring. Inside the bowl is contained a number of concentric conical discs, which rest one upon the other, with a spacing of about one-sixteenth of an inch between each pair. The spaces between the discs are open at top

and bottom, and their object is to spread the milk into very thin layers. The milk being led in from the constant level chamber to the central feed tube, passes into the spaces between the discs and becomes exposed to the centrifugal force of the whirling bowl.

As a result, the heavier particles of the milk are flung to the outer edges of the discs and pass out into the skim milk spaces. The fat globules, being light, pass out of the inner spaces. In the central tube the cream encounters a pressure due to the incoming milk and is forced up to the top of the tube, whence it passes out by the cream regulating screw. This is a hollow screw which projects into the central space and provides an outlet for the cream. It allows the thickness of the cream to be varied. The purest and therefore thickest cream is found at the centre of the machine, and that mixed with some milk at the outside. Therefore if the screw is right home the layer of cream on the outside is not directly passed out, only the thickest part flowing through the screw.

There are many well-made separators on the market to-day which can be depended on to give good service for many years if properly handled, but a good machine can soon be ruined if the maker's directions are not followed.

It is important that the correct speed, as stated on the machine, should always be maintained, and that maker's settings, such as the rate of feed of whole milk, should not be tampered with. Temperature is a vital factor in separation, which is done most efficiently when the milk has just left the cow. If it is allowed to become cold the separator will not deal with it effectively, and it must be warmed before putting it through the machine.

The separator must be carefully lubricated with special oil and attention paid to its cleanliness. After all the milk has been put through, a little clean warm water should be put in to flush out any cream left in the bowl. The separator must then be thoroughly cleaned, the bowl being taken apart for this purpose. Special attention should be paid to the cream outlet.

When putting the discs in place, it is often necessary to replace them in a definite order. Some pressure is needed to force them down in place, and the bowl top is screwed down to a certain mark. In doing this, care must be taken to get the discs correctly adjusted, or they may be damaged when bolted down. The rubber ring should be kept in good order and replaced if any milk is found leaking into the outer casing.

The separator should always be firmly secured, if possible to a concrete floor. A power drive is preferable to hand turning, especially on account of its steadiness. Where electricity is available this is the best form of power for the purpose.

There are several types of bowl other than that described in use, one of which is exemplified by the Diabolo. In this the conical discs are replaced by a number of curved plates, all strung on a central ring, which occupy a vertical position when in place.

CHAPTER XVIII

THE THRESHING MACHINE

THIS is one of the largest and most expensive single pieces of machinery in use on our farms. It has been the custom in most districts for threshing machines to be owned almost solely by contractors, who did the threshing for the farmer at a fixed charge. Since the tractor has become common, however, the tendency is for farmers to buy their own threshing boxes and drive them with the tractor. Where the farm is of sufficient size it is naturally much cheaper to thresh in this way than to employ a hired steam threshing set.

The various standard makes of threshing machine vary very little in principle of action. The sectional drawings (Figs. 112 and 113) represent a Ransome's box, and these should be carefully studied and the course of the corn through the machine followed.

The chief part of the work is centred in the drum, which actually separates the corn out from the ear. The rest of the working parts are concerned with the separation of the corn, straw, chaff, etc., and cleaning the grain.

The drum is situated high up in the box, towards one end. It is built up chiefly of steel on a spindle which runs right through the box and carries at one end the main driving pulley.

As will be seen from Fig. 115 the drums pindle carries a number of discs or chairs, rigidly fastened to the spindle at intervals. On the periphery of these chairs are mounted the beaters, running parallel to the spindle. These are made up of beater bars and beater plates. The beater bars have a plane angled face, to one side of which is bolted the beater plate. The latter is ribbed in order to prevent

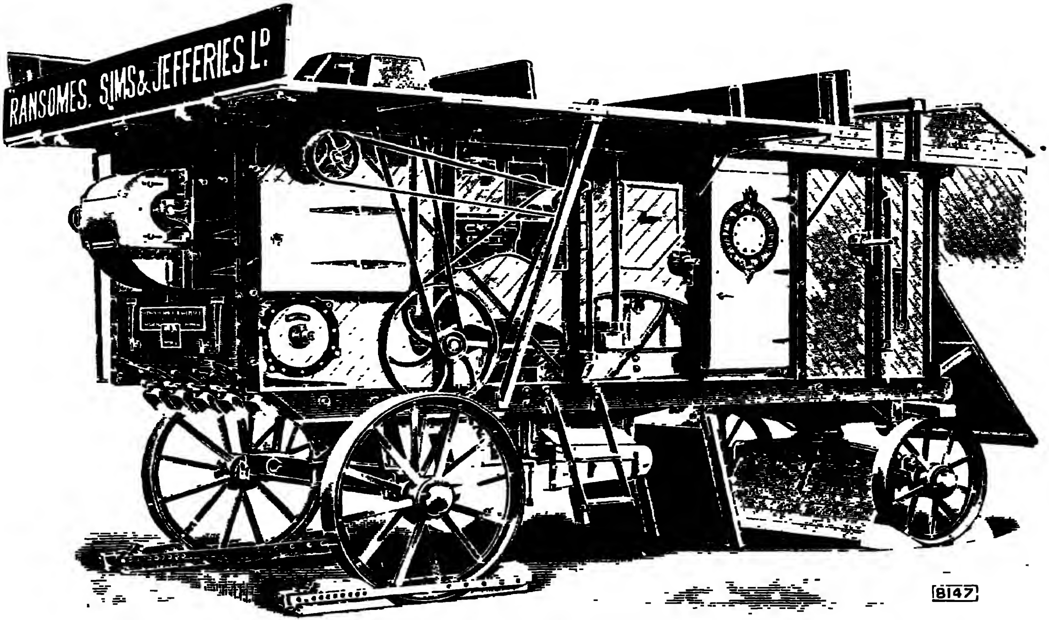


FIG. 114. A typical British finishing threshing machine

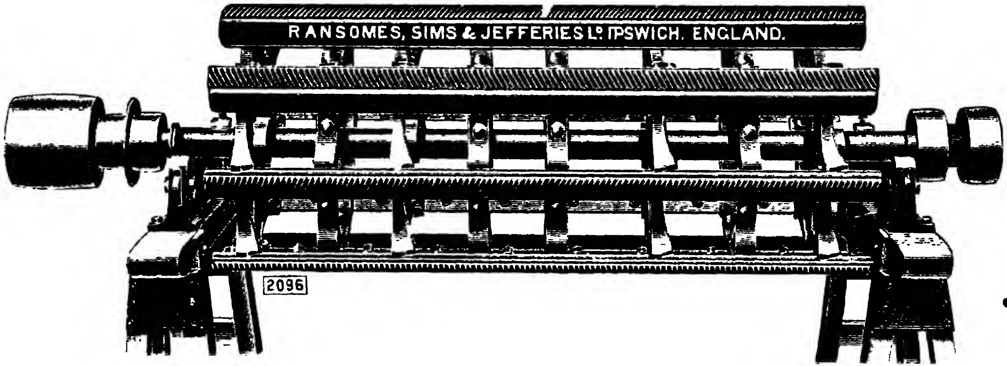


FIG. 115. A threshing drum

crushing of the corn. The smooth face of the beater bar leads up to the ribbed beater plate at an angle and gives a large rubbing surface while avoiding any tendency to damage the straw.

Situated round the lower half of the drum is the concave. As the drum corresponds to the old-fashioned flail, so the concave corresponds to the threshing floor, and between the two the actual separation of the grain from the ear is effected.

The concave consists of a grating made up of wrought iron wires. This extends the full width of the drum and is supported on the sides of the box. The supports are so arranged that by means of adjusting screws on the outside of the thresher the distance of the concave from the drum can be varied as required. The concave is generally made in two halves, both reversible, end for end, so that extra wearing surface is given.

The corn is fed into the machine from above, through the mouth, either sideways or ears first according to the custom of the district. As it passes between the drum and the concave the grain is knocked out and falls through the bars of the concave, together with small pieces of chaff, etc. The straw is drawn right through and thrown out in front of the drum on to the straw shakers.

These are long, light wooden boxes which slope up from near the drum to the end opening of the thresher. The number employed varies according to the width of the machine. These boxes are mounted on crank shafts at each end, and while the machine is running they have a continuous reciprocating motion, tossing the straw upwards and forwards at each stroke. In some cases there is only one crank shaft, in which case the motion is somewhat different. As the straw passes over these boxes, any grain which may have passed out with it, together with chaff and cavings, is shaken out and falls clear of the straw.

In order to regulate the speed at which the straw passes over the shakers, and to check any grain which may fly out from the drum, check plates are hung at intervals above the shakers. These are hinged and may be set at

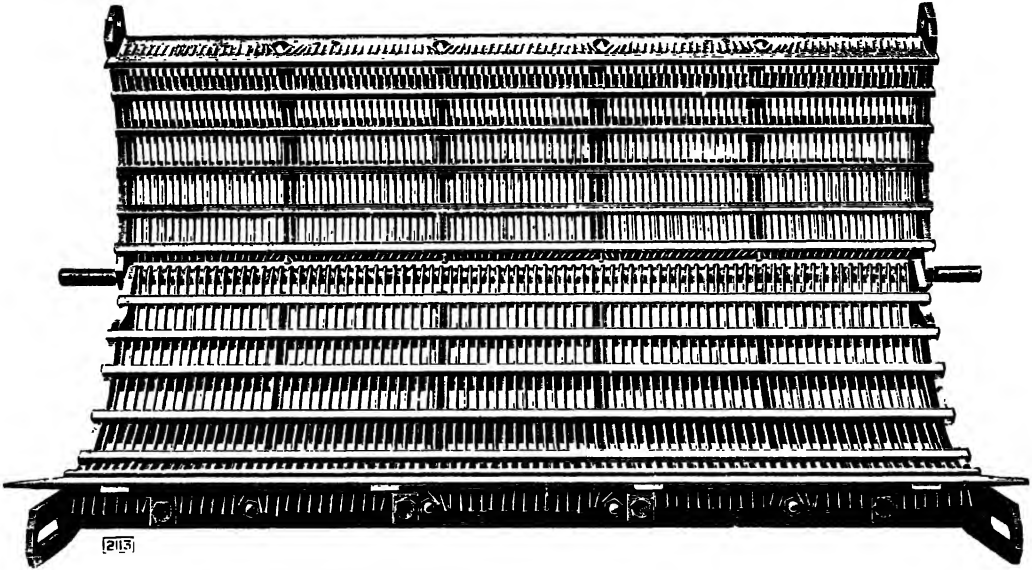


FIG. 116. The concave which partially surrounds the drum

any angle so as to bear more or less on the straw. The straw, reed from small stuff, is delivered out of the end of the machine on to the straw board, where it is dealt with by hand or machine.

The grain falling through the concave drops on to the first receiving board, which is inclined, and which passes grain, chaff, and cavings from the shakers on to the cavings riddle. This is a long, reciprocating screen which allows everything but the cavings to drop through. It slopes down towards the open end of the box where the cavings are delivered. The riddle is supported by hangers made of ash. These are flexible and allow of the screen being pushed to and fro by crank motion. This method obviates the friction and necessity for lubrication which would arise if the riddle ran on slides.

All grain, etc., falling through the cavings riddle drops on to the second receiving board, which passes it on to the first dressing shoe. Here the chaff is separated by a blast of air directed up through the sieve. The light chaff is blown away from the grain and chobs, and is delivered out of the side of the machine. The grain and chobs fall on to a second set of sieves, which separate the chobs and small weed seeds. The grain, now comparatively clean, passes to the elevator.

This consists of an endless band passing round drums at the top and bottom of the machine. On the band are a number of metal cups. The band being driven by means of a belt acting on the drum pulley moves continuously round the two drums. As each cup passes through the well at the bottom of the elevator it picks up a quantity of corn and carries it to the top. On passing over the top drum the position of the cup is reversed, and the corn is poured out into the awner or hummeller. This is situated across the drum end of the machine and may be used or cut out as desired, the object being to remove undesirable portions adhering to the grain, such as the awns of barley or the hard chaff of wheat.

The awner consists of a barrel made either of cast iron

or steel wire. Inside this a spindle passes right across the machine and carries knives and rubbers to give a churning and polishing action to the grain. The design of the hummeller varies in the different makes. The first section

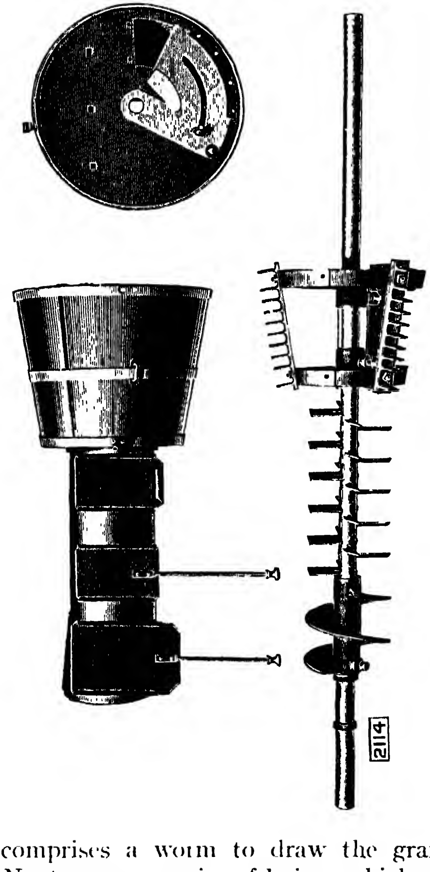


Fig. 117. The components of the Ransomes awner or hummeller

usually comprises a worm to draw the grain into the barrel. Next comes a series of knives which revolve with the shaft and cut off the awns of barley. The grain is then subjected to a rubbing action in the end part of the

awner, which may be conical in shape. In some cases all the polishing takes place in one section. Adjustments are provided so that the time that the grain is subjected to the action of the awner can be varied.

From the awner the grain falls on to the second dressing shoe, through the sieves of which a blast of air passes. All impurities are thus blown away and pass out of the machine with the chaff. Any grain not properly polished is retained by the sieves and returned on to the first receiving board, passing through the machine a second time.

On leaving the second dressing shoe, the grain passes to the rotary screen, where it is graded. This screen is made up of wires forming a cylinder and mounted on a spindle running across the box. At one end the wires are closer together than at the other. Consequently, as the grain is led in at the end, where the wires are close together, the small grain and any weed seeds fall through first. This is the tail corn. As it drops through the screen it is delivered by a spout to a sack placed to catch it. Similarly, farther along the screen the second grade is separated, and at the end the head or first quality corn is delivered. The last does not pass through the mesh of the sieve but falls out of the open end. The whole of the screen is adjustable, so that the mesh can be altered to suit different grains. This is accomplished by means of a thrust screw, which acts at one end of the spindle and puts more or less compression on the wires. Bearing on the upper face is a round brush running the whole length of the screen. As the latter rotates this brush serves to remove any grain which may stick between the wires.

If it is not desirable to pass the corn through the awner it is generally possible to drop it directly to the corn spouts or on to the second dressing shoe, while it is sometimes possible to pass it through portions only of the awner.

The air blasts are furnished by powerful fans, of which there are usually two—one close to the bottom of the elevator and one high up at the end of the box over the

rotary screen. The blast from the first fan is generally divided to serve both the cavings' riddle and the first dressing shoe. The second fan delivers blast to the second dressing shoe.

When setting up the machine for work, care must be taken to get it exactly level, as indicated by the spirit levels set in the sides. This is done on uneven ground by means of blocks or special lifting chocks, which can usually be supplied to order.

The concave must be adjusted in accordance with the maker's instructions, being set close to the drum at the lower edge and farther away at the mouth. A fairly wide setting should be given at the start, and gradually decreased. The correct sieves for the grain to be threshed must be put in the dressing shoes. The right mesh for any particular seed may be found by trying some of the grains through the sieves.

The engine must be properly lined up with the thresher so that the belt runs true, and the drum must be got up to its full speed before putting any corn through.

After threshing has commenced, a careful examination must be made of the products coming from the different outlets. If the corn is cracked, the concave is probably set too close to the drum, while if the straw comes away with corn still in the ear, the concave needs closer adjustment. If much loose corn is carried out with the straw, the check plates need setting lower to retard the straw. They should not be set so low, however, as to prevent the straw coming out quickly enough. If corn comes out in large quantities with the chobs, these should be put through again. The blast over the chaff sieve must be carefully adjusted for corn of different weights. For example, only a small opening can be given when threshing light oats.

The work of the awner must be carefully watched, especially when threshing malting barley. All driving belts must be kept at the right tension when running, as otherwise a choke may occur. Leather belts should be

greased from time to time on the outside, and a good proprietary belt dressing used on the driving side of all belts. While working, all bearings need to be carefully watched for any signs of heating, which, however, is not likely to occur if lubrication is properly carried out. When stopping at night, the machine should be left with the drum in such a position that the flexible wooden hangers of the dressing shoes are hanging straight down, thus relieving them from strain. When any job of threshing is finished, the machine should be thoroughly cleared out so as to be free of corn, etc.

TABLE 16

Size of Drum			B.H.P. required	Output of Wheat in bushels per hour
ft.	in	in		
4	6	22	20	40-80
4	0	22	18	30-60
3	6	22	16	25-50
4	6	20	18	30-60
4	0	20	16	25-50
3	6	20	14	20-40
3	0	20	12	15-30

The operation of the standard machine calls for a considerable amount of labour, but several accessory machines can be employed to reduce this.

The self-feeder is made in several types, employing some form of conveyer, frequently a travelling apron, to lead the sheaf into the drum. The sheaf is thrown on to the conveyer by the band cutter, and is broken up and spread out by oscillating tines, fitted above the conveyer. In some makes, drum conveyers are used, while occasionally a governor is employed to cut out the feed when the speed of the threshing drum falls below normal.

The Foster stack feeder dispenses with any labour on

the thresher, and enables the drum to be fed from the stack.

It comprises a counterbalanced conveyer trough, which can be set to the ridge of the stack when starting, and gradually falls with the stack, until it elevates the last sheaves to the drum from the ground level. The bands

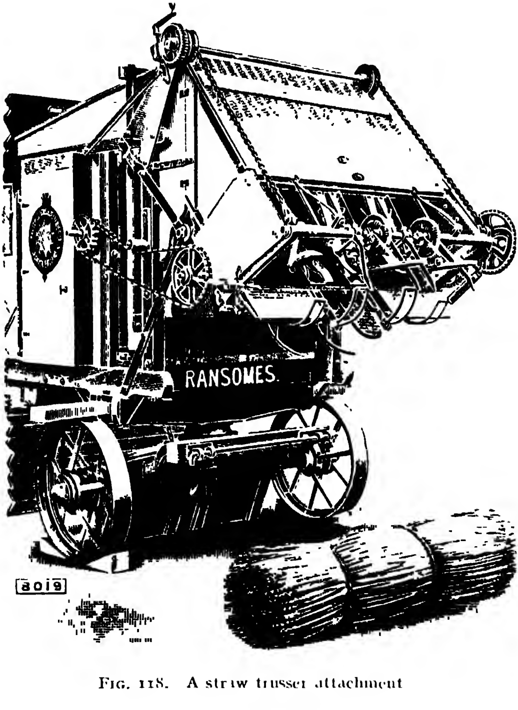


FIG. 118. A straw trusser attachment

are cut by revolving discs above the trough and the sheaves opened out by a combing cylinder. A governor regulates the speed of feeding and prevents choking of the drum.

A good deal of labour can be saved by mechanical handling of the straw. For this work the elevator may be

employed if the straw is to be stacked. The trough is brought right under the delivery end of the box, the straw board leading into it. The elevator is driven by belt from a convenient pulley on the thresher, unless it is of the type fitted with self-contained engine.

If the straw is to be carried away it can be tied up by means of a straw trusser attachment. The straw board in this case leads down to a binding table, similar to that on the reaper and binder. Two binder attachments are employed, timed together, thus putting two bands round each truss.

In suitable circumstances a very convenient method lies in using a silage cutter and blower to cut the straw as it comes from the machine and blow it away into the barn. Very little extra power is required for the cutter, and the only adaptation necessary is in the blower pipe, for which a suitable bend must be obtained. In some cases the cavings, etc., can also be put in the cutter trough and blown away with the straw chaff.

CHAPTER XIX

THE ENSILAGE CUTTER

THIS machine is more or less a development from the chaff cutter, but comprises arrangements for blowing away the cut fodder.

The machine is mounted on a wheeled truck for transport purposes. The belt conveyer, similar to that on a chaff

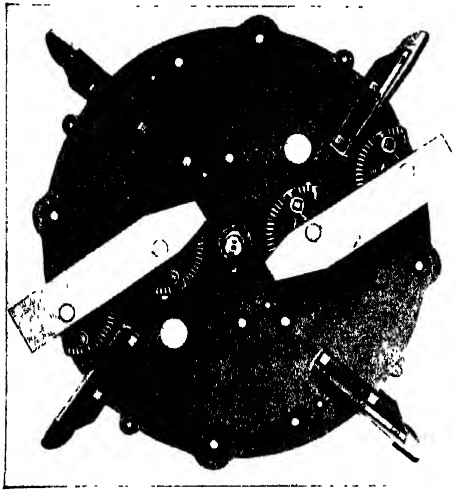


FIG. 119. The flywheel of the Massey-Harris "Blizzard" cutter

cutter, passes through a long feeding trough. The web is best constructed entirely of steel. The forage is led by the conveyer to a pair of feed rolls, of which the upper is floating. These pass the material on to the shear plate to be cut. In some machines an extra roller is provided to assist in feeding in. The knives are mounted on a heavy

flywheel, which is enclosed in a casing. This casing communicates directly with the blower pipe, up which the

FIG. 120 Diagrammatic section of a concave type of knife, showing how it grips the fodder

silage is blown when cut. The flywheel carries, in addition to the knives, a number of fan blades, which just clear the walls of the housing. Thus a strong draught is created

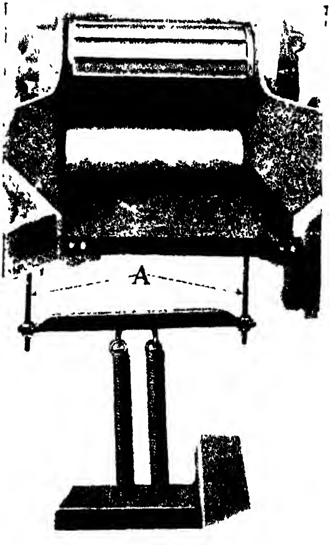


FIG. 121. The feed rolls on the "Blizzard." A indicates the rods which transmit the spring pressure to the floating roll

when the machine is running, sufficient to elevate the fodder to any required height.

The flywheel should be built up of steel plate, and the knives, of which there are several types, must be adjustably mounted, in such a manner that their removal for sharpening does not disturb the setting. The flywheel is carried on the main shaft, which passes through the body of the machine, having a long bearing at each end. Mounted on this shaft are the driving belt pulley, and also the primary gears for driving the rollers and the conveyer. A clutch is embodied which enables all parts except the flywheel to be stopped at will. The drive to the feeding web is taken through variable speed gears, so that the speed at which the belt travels can be varied with respect to the flywheel speed. This is the usual method by which the length of cut is altered. The clutch, with forward, neutral, and reverse positions, is generally controlled by the standard type of lever placed across the mouth of the machine.

The general run of machines take from 10 to 20 h.p. to operate at from 1,000 to 600 r.p.m. The capacities vary considerably according to the nature of the material cut, and most machines are rated on the basis of cutting maize. The rate of cutting tangled crops, such as tare mixtures, is very much less.

The pipe must be erected as nearly as possible in a vertical position, and the joints well made to prevent excessive air leaks. The projecting end of each section inside the pipe must point upwards, so as to leave a smooth passage for the silage. A hood and deflector are used to carry the pipe over and down into the top of the silo. In some cases a down distributor pipe is provided, to permit of the fodder being directed into any desired position in the silo. If a distributor is not used the silage is deposited in a heap and has to be spread by forking.

The lawn mower type of cutter differs from the above in having a spiral knife mounted on a cylinder, similar to that of a lawn mower, from which the name is taken. The fan is situated in this case at the side of the machine, and the cut fodder is conveyed to it from the knives by means of a worm or similar device.

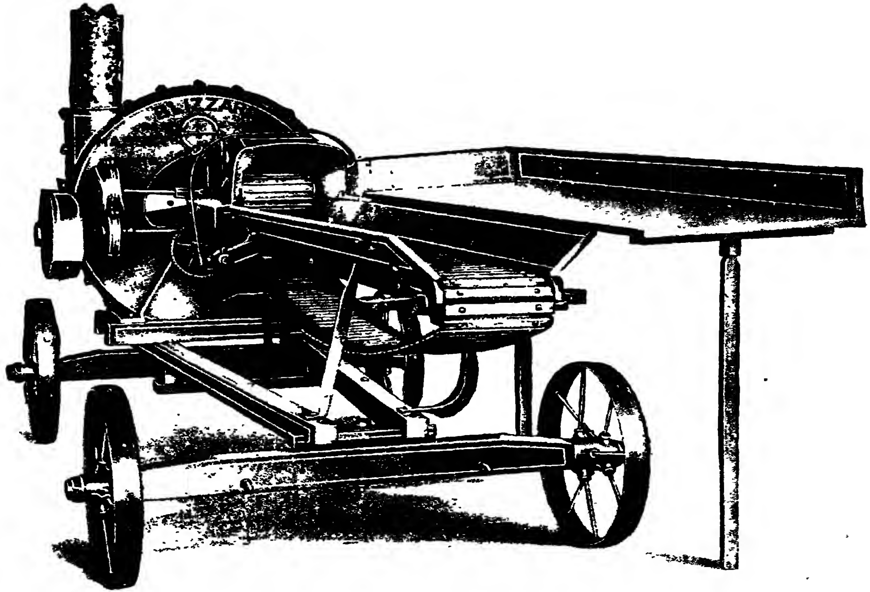


FIG. 122. A typical ensilage cutter and blower, showing the flywheel casing, blower pipe, conveyer, and feeding table

In adjusting the knives care should be taken not to set them too close. About one-sixteenth of an inch is the correct clearance on most machines. If necessary, the whole cutter head can be moved to or from the shear bar by means of set screws at each end of the main shaft.

The silage cutter can be used, if desired, for chaffing straw, but the average machine is not suitable for cutting hay into short chaff, owing partly to the difficulty of keeping the machine fully fed, and partly owing to the fact that it is necessary to run the knives at a high speed. This tends to powder the hay. There are also other difficulties in practice which prevent the use of the ordinary silage cutter for this work.

In feeding the machine with green stuff, it is necessary to avoid forcing in too great a quantity at one time, as this slows down the speed and is liable to cause a choke in the blower pipe. Should the feed rolls become jammed it is necessary to reverse the feed web to clear. It is dangerous to put the hands close in to the rollers in an attempt to force the block through. The fan housing must be securely closed when running. Care should be taken to prevent stones or other hard substances getting into the cutter. When the machine is on loose ground a sheet should be put down to receive any fodder that falls or is deposited on the ground.

CHAPTER XX

ELEVATING AND CONVEYING MACHINERY

THE elevator, which is suitable for stacking hay, straw, or corn, consists of a long, inclined trough mounted on a transport truck. The trough is usually in sections in order that the machine may be folded for storage. Passing through the trough is an endless web carrying forks, by means of which the hay is carried up to the top. This band may be situated either in the floor of the trough or over the top, in which case the hay slides on the bottom of the trough. The moving web is driven by a small engine, either built in on the frame of the elevator or portable. When working in conjunction with a thresher the elevator is driven by belt from the machine. From one to two horse power is usually sufficient.

The design of the hopper at the foot of the trough varies slightly according to requirements. For use with hay sweeps, the hopper can be made extending down on to the ground, to facilitate feeding. The majority of elevators are very heavily built, and it is possible that a lighter type will eventually be designed. In many cases quite a satisfactory light machine could be cheaply built on the farm.

In hay stacking operations, the use of the elevator means that the hay must be hand pitched from the load into the hopper. To expedite stacking, many farmers prefer to use the grapple fork, which enables the hay to be put up in large bunches very rapidly.

When this tackle is to be used it is necessary to erect one or two poles at the site of the stack, unless stacking in a Dutch barn, when the necessary tackle can be fixed to the roof.

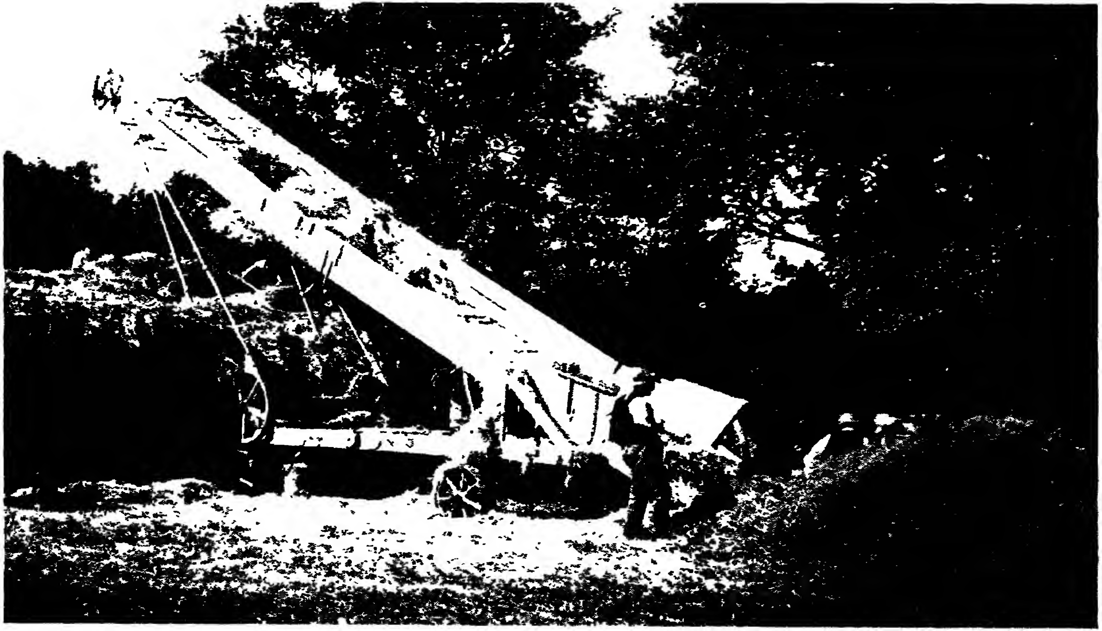


FIG. 123. Stacking hay with a power driven elevator

Where a single pole is used it is placed at the side of the stack. It has attached to it a swinging jib, which may be either short or long. If a long jib is used the upright pole need not be very high. To the point of the jib is attached a pulley, over which runs the rope to which is attached the fork.

There are a number of different types of fork, of which the grapple fork is probably the most generally useful. This has hinged arms, which grip the hay in the same manner as ice tongs, until released by the pull of a cord. Another type is the harpoon fork, which is plunged into the load. On being hoisted, the prongs of the harpoon open out and lift the hay. To deposit the hay, the operator pulls a cord which causes the prongs to turn downwards and release the hay.

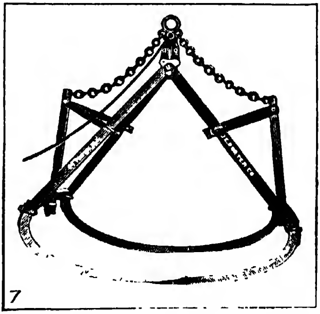


FIG. 124. Grapple fork for stacking hay (Geo. W. King)

The lifting is best done by means of a small portable engine coupled up to a winch, around which the end of the rope is passed. This outfit must be provided with a clutch and brake. To raise the fork, the clutch is thrown in until the fork reaches the required height, when the brake is applied and the clutch thrown out. To lower, the brake is released. The operation can also be done by hitching

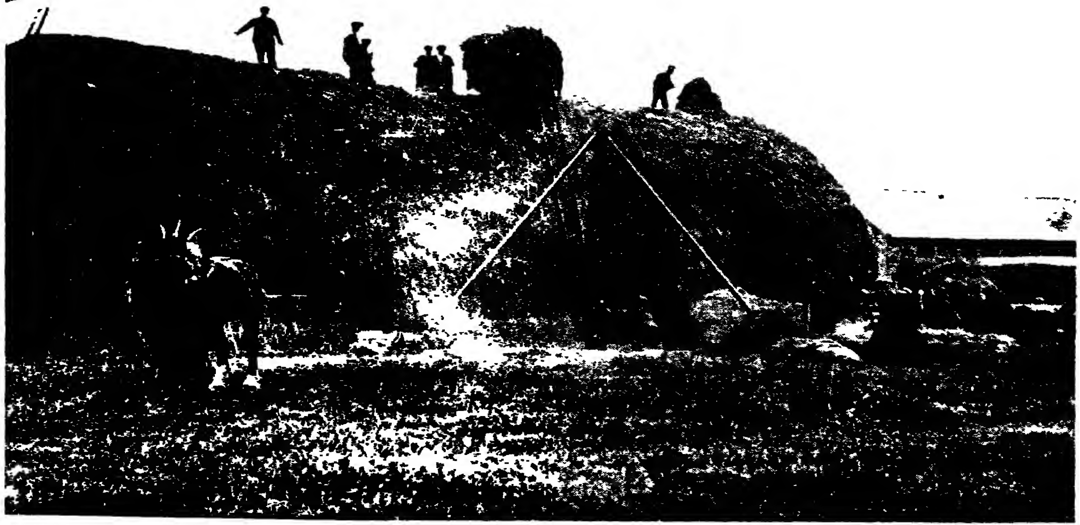


FIG 125. Putting up hay with a horse fork

a horse to the end of the rope, which must in this case pass round a pulley near the ground. To raise the fork, the horse is driven away from the stack.

The same type of engine hoist as described above for stacking hay can be used for many lifting operations when suitably modified. Amongst these are the hoisting of

FIG. 120. The Alexander portable pow[illegible] loading dung

sacks of grain into the granary and the loading of dung. For the former job a sack lifter is attached to the rope, and for the latter a manure grapple fork.

Elevation and conveying of many light materials can be carried out by means of a blower pipe, such as used on the silage cutter. With the aid of an extra long bend suited to individual circumstances the silage cutter can be used

to cut and blow straw a considerable distance into the fodder barn, as suggested in the section on Threshing.

For the conveyance of fodder and manure, in the cow house and other stock houses, the overhead carrier system offers great advantages in many cases. To get the best out of these conveyers, the buildings really ought to be

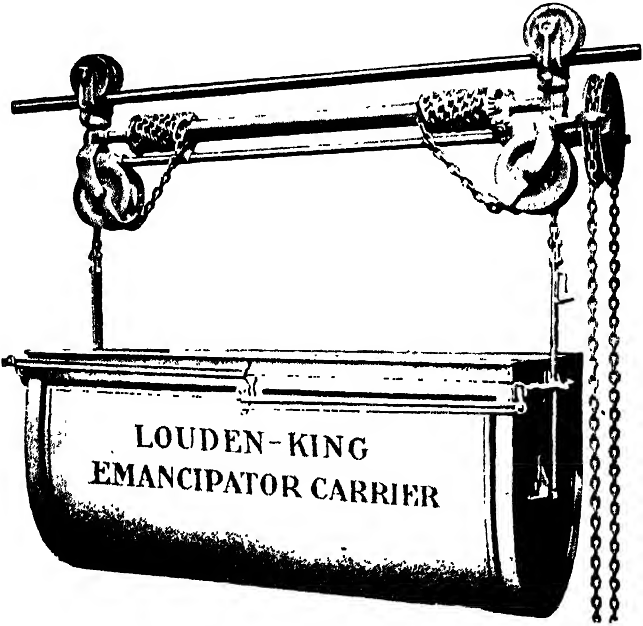


Fig. 127. Carrier for manure and fodder

designed with a view to their use, but often the arrangement of existing buildings is quite suitable for an installation.

The modern overhead track system gives silence in operation, considerable flexibility, and necessitates no obstructions on the floor space. A great deal of hand labour is saved by its judicious employment. Thus, the

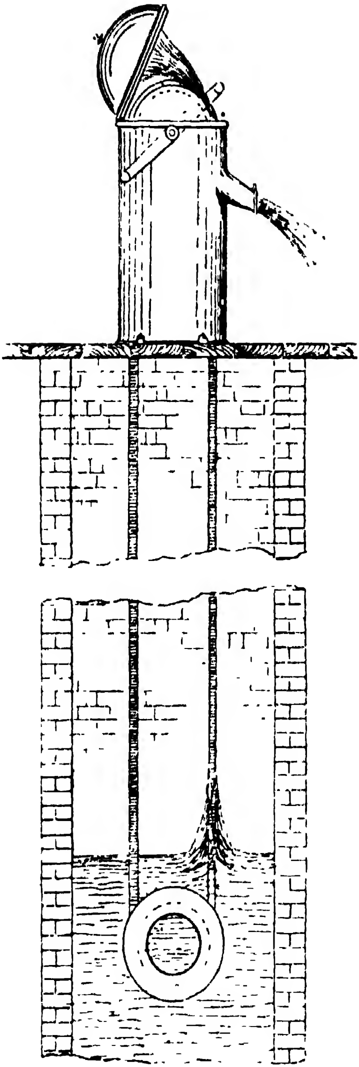


Fig. 128. Diagram of the Crawley hydrohoist

carrier can be easily lowered for filling with manure and then raised to a convenient height for tipping straight into the dung spreader or on the manure pit outside. The fodder carriers are, of course, just as easy to operate. With a central mixing floor, and a carrier system, the food

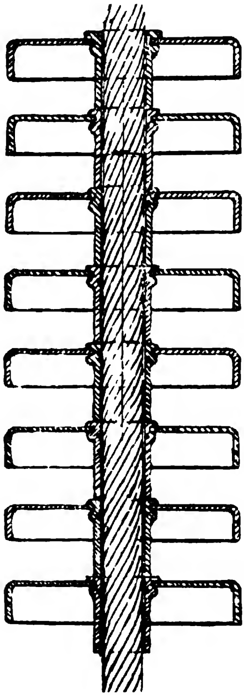


FIG. 129. Detail of the hydrohoist cup rope

can be distributed to the various buildings with the minimum of labour.

For lifting water from deep wells, a very satisfactory device is some form of elevating band. There are several makes of these, the general principle on which they all

work being shown by the illustration of the Crawley hydrohoist.

A hand- or engine-driven drum (according to the depth of the well) is placed at the well head. Over this runs a special band covered with cells of various forms. The band extends down into the well below the water level, and a deep grooved "diabolo," suspended in the band, keeps it running true.

On the drum being rotated, the band is put in motion, and the side which is rising lifts with it a quantity of water, which is discharged at the top into a receiver, whence it is led to the receiving tank.

One type of cell is illustrated, and in this the lift is both positive and by capillary action. The capacities of these elevators may range up to 20,000 gallons per hour or over, on lifts of several hundred feet.

CHAPTER XXI

PUMPS AND SPRAYING MACHINERY

ON comparatively few farms is there any main water supply, and the common method of raising water from wells is by means of pumps. The most usual type is the so-called suction pump.

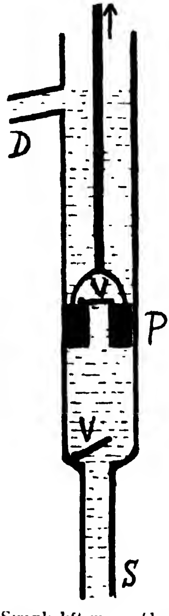


FIG. 130 Simple lift pump (diagrammatic)
D, delivery pipe; VV, valves, P, piston, S, suction pipe

This operates not by suction but by atmospheric pressure. At sea-level the weight of the air is sufficient to support a column of water about thirty-four feet high in a cylinder

which has no communication with the atmosphere at its upper end.

In the common lift pump, a piston fits in the barrel of the pump, making an air-tight fit by means of a leather washer. A hole passes through the centre of the piston and

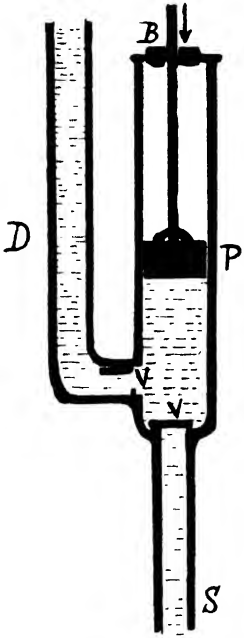


FIG. 131 Diagram of a force pump
D, delivery pipe; B, packing gland, P, piston, VV, valves; S, suction pipe

is fitted with a non-return valve. At the bottom of the barrel is a second valve communicating with the pipe leading down into the water. An up stroke of the piston creates a partial vacuum in the barrel, and water rises in the pipe as a result of the air pressure outside the barrel and pipe. This water passes through the valve at the foot of the barrel while the piston is rising. As soon as

the piston descends the lower valve closes, holding the water in the barrel. The valve in the piston opens, and the water rises through it into the upper part of the barrel. On the next up stroke of the piston the upper valve shuts,

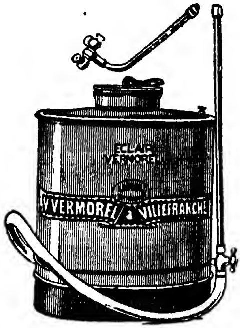


Fig. 132. A 3½-gallon knapsack sprayer

and the piston lifts the water out into the delivery pipe, while a fresh supply rises into the barrel. To start these, and many other types of pump, it is often necessary to prime them by pouring water into the barrel.

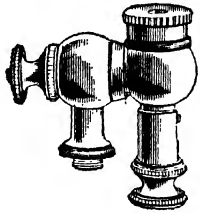


Fig. 133. Vermorel adjustable n

By connecting both ends of the barrel with the inlet and outlet pipes, we can increase the output of a lift pump and make it double-acting. A jet is then discharged from the outlet for every stroke of the piston, instead of for

every other stroke. Pumps of this type will also work in a horizontal position and horizontal double-acting pumps are commonly used for operation by power.

In a force pump, the inlet and outlet are both at the lower end of the barrel and are controlled by non-return valves as in the case of the lift pump. Water is drawn into the barrel on the up stroke and forced out of the outlet pipe on the down stroke. Ram or plunger pumps

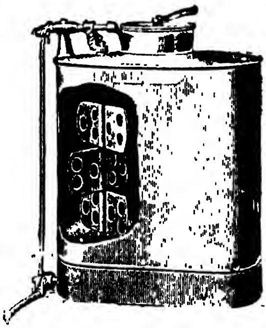


FIG. 134. Eclair knapsack sprayer showing agitator

are similar in action, but the portion of the piston which constitutes the plunger is of smaller diameter than the barrel and acts by displacement. This type is less liable to jam if grit gets into the barrel than the full piston force pump.

The type of valve used in these pumps varies very much in accordance with the class of work they have to perform. On the common single lift pump, simple leather-flap valves are used. For higher speed pumps a mushroom or poppet valve is often employed, while in engine-driven horizontal pumps, ball valves are fairly common. The solid rubber ball valve shows special advantages in situations where it is possible to use it.

Centrifugal and rotary pumps are not used to any great extent on farms in this country. The centrifugal pump

is similar to a turbine; but, of course, acts in the reverse way. It is of great importance in raising large volumes of muddy water for irrigation purposes.

The rotary type employs two pinions geared together, each carrying two large teeth of special form. Water is taken in at one side of the chamber containing the pinions and delivered at the other, being carried round the sides of the chamber by the large teeth.

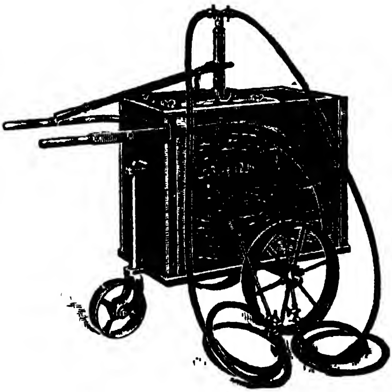


FIG. 135. A Stonehouse manual sprayer

SPRAYING MACHINERY

On fruit and hop farms, spraying machinery is of the first importance, since both fruit trees and hops are subject to such a large number of insect and fungus pests that only by efficient spraying can a crop be ensured. Spraying equipment has to be capable of throwing a mixture of chemicals and water in one or more jets of fine spray.

Equipment is made in a wide range of sizes to suit varying requirements. The majority of spraying machines comprise a container for the fluid, and a pump by means of which sufficient pressure may be raised in the container to force the fluid out of the machine through the fine jet which is provided. In addition most sprayers have an

agitator fitted inside the container to keep the spray thoroughly mixed, while various other accessories are needed.

The smallest type is the knapsack sprayer, which is slung on the shoulders of the operator and holds about two gallons. A lever fitted at the side projects forward and allows the operator to keep the pump working while he is spraying. The pump is fitted inside the container, and forces the spray out through a short length of rubber hose, and a metal lance, at the end of which the spraying jet is fixed. A tap is fitted on the lance to enable one to shut off the spray at will.

Next in point of size comes the hand-propelled tank sprayer, which has a spray tank mounted on wheels, and a pump which may be operated by one or two men. Higher pressure can be attained with these machines, and they will carry to a greater height than a knapsack sprayer, while the pump may serve several different jets.

In the case of sprayers larger than this it becomes necessary to fit an oil engine to operate the pump, and the machine is then equipped with shafts and hauled by a horse. A horizontal slow-running paraffin engine is used, generally coupled through a train of gears to the pump crankshaft, operating a two- or three-barrel double-acting pump.

In these larger outfits it is necessary to provide a pressure gauge and a relief valve to guard against excessive pressure being generated. Long hoses are provided, ending in a bamboo lance which may be some ten feet in length. These enable the spray to be easily controlled and delivered at a comfortable distance from the worker.

The vital part of any sprayer is the jet, since it must be constructed with a very minute aperture in order to produce a misty spray, and yet must be capable of being easily cleared if it gets clogged. Since much of the material used in spraying is not fully soluble in water, this is a fairly frequent occurrence.

Many jets are built with a spring needle lying just behind

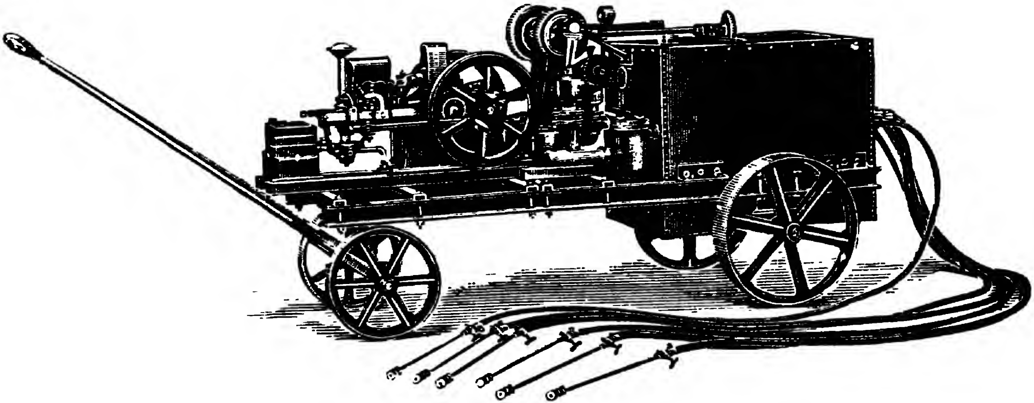


Fig. 136. Stonehouse power-spraying outfit

the jet orifice, which can be quickly pushed through the hole to clear an obstruction. In the Vermorel type of jet a whirling action is imparted to the spray before it leaves the jet chamber.

A special type of cart sprayer is used for spraying potatoes and also for destroying charlock. It comprises a large barrel mounted on a cart-frame, the pump being geared to one of the wheels.

Dry spraying is coming into favour for fruit and is likely to spread. Various powder sprayers are on the market, some having been developed from the hop sulphurator.

While there is no standard type, dry sprayers must include a container, with a variable feeding device and some means of generating air pressure to deliver the dry spray as a cloud of dust. Commonly a fan is used, but in one case the exhaust from an oil engine is utilized.

CHAPTER XXII

FARM TRANSPORT

THERE are certain problems connected with farm transport which present difficulties but which can generally be solved by the exercise of some ingenuity. These are chiefly connected with the widely varying surfaces over which farm vehicles must pass.

We have three types of transport available for agricultural purposes, namely, horse and tractor haulage and the motor lorry. Horsed vehicles have the advantage of being immediately adaptable to all conditions. They can traverse a wet, ploughed field and then proceed along a hard road. Where, however, a farm is worked mainly by mechanical power it may not be economical to keep sufficient horses to do all the haulage. Horse haulage in any case is slow and expensive, for only a few ton-miles are within the capacity of each man operating a horsed vehicle.

The average light tractor can haul loads of four tons on ordinary roads, at a speed of five m.p.h. if equipped with rubber tyres. It can also haul over bad surfaces when equipped with strakes or spuds as used for ploughing. The use of a traction device, however, is not permissible on hard roads. The tractor therefore can haul from the field to the farm via rough farm roads, but for regular road haulage usually needs rubber tyres. It is fairly speedy, cheap to operate, and the capacity in ton-miles per day is high.

The lorry is of special value where regular road work is the rule; on such work as the delivery of milk or vegetables into a town it is almost indispensable. It is of further

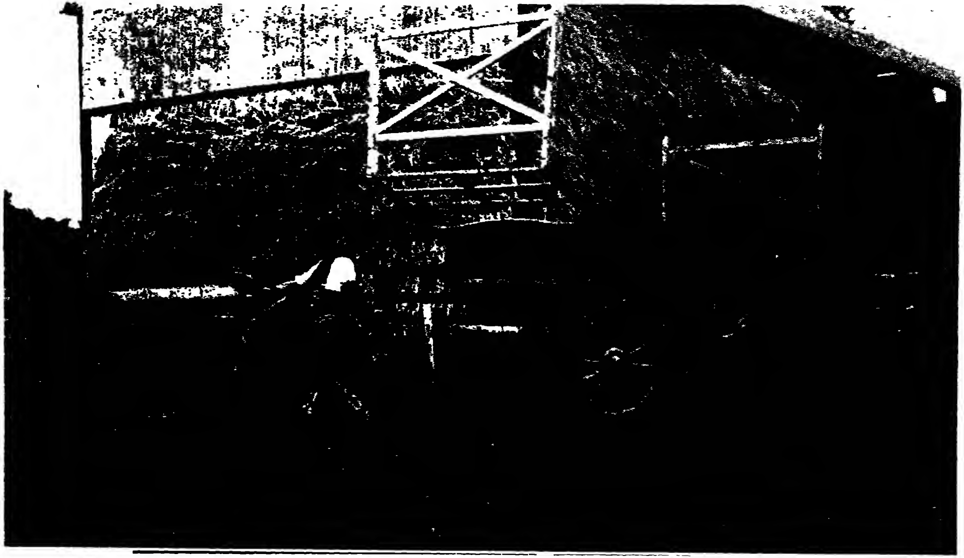


FIG 137 Fordson tractor and wagon equipped with high lades to increase the capacity

value on the farm in carting hay and corn from the harvest field, general carting when the land is fairly dry, and it can also be fitted up for belt work. It can traverse fairly greasy fields when fitted with non-skid chains, while the four wheel drive type can negotiate practically any surface, no matter how bad.

The lorry is much faster on the road than either horses or the tractor, thus rendering the capacity high, and giving a great advantage in the marketing of perishable produce. Lorries of widely varying types are obtainable for farm purposes, of capacities from a few cwts. (suitable for the poultry or fruit farmer) up to four or five tons, or even more. For average mixed or dairy farm purposes the two tonner is probably the most generally useful, although small dairy farmers largely employ a one ton truck.

Bodies of all types, some specially designed for carrying live stock, and others for milk churns, are now on the market, and no difficulty should be experienced in getting a lorry suitable for any special service.

On the great majority of mixed farms, where road haulage can be done chiefly at times when the land work is slack, there is no doubt but that tractor haulage will be found the most economical. Much depends on the way the tractor is fitted for the work and the method of adapting existing horse wagons and carts for the purpose. It is usually necessary to make a light iron or steel drawbar to hook on to the wagon, with an eye coupling for attachment to the tractor. It is sometimes desirable to retain the shafts so that the vehicle can be drawn by either horse or tractor. In this case the shafts should be hooked up out of the way for tractor use, and the special drawbar made easily attachable. In this way it is possible to haul heavily loaded wagons over bad ground with a tractor fitted with ploughing strakes and turn them over to horses on a hard road. Such organization of work is a matter for decision on any particular farm since conditions vary so widely; the necessary equipment must therefore be designed to suit individual requirements.

Much may be done to improve the conditions of transport on the farm by giving attention to the private lanes and tracks. While it would seldom pay to make any large expenditure in this direction, any reasonable amount of labour spent in slack times on improvements and repairs would always effect a reduction in the haulage costs. The amount of power required to haul a wheeled vehicle of given weight depends, apart from gradients, entirely upon the surface traversed. It rises enormously on deeply rutted and loose ground.

As regards the materials used for farm road making the cost determines the choice. In districts where stone is plentiful, and is to be had for the getting and carting, excellent roads can be made at small costs. All districts are not so favoured however, and the problem of material is often a difficult one. Where they can be obtained cheaply, old railway sleepers make a very serviceable " corduroy " road, when laid side by side across the road. These are often too costly to use extensively, but can be replaced to some extent by rough timber in well wooded districts. Near towns waste clinker and other hard material can often be carted free from the refuse incinerators and can be usefully employed in road making.

Whatever the materials used, it is important that all roads should be drained as well as possible, although only surface drainage is usually possible. If the road is raised well above the ditches, and the watercourses are kept clean, not much trouble should be experienced with flooding.

CHAPTER XXIII

ELECTRICITY ON THE FARM

THE possession of a supply of electricity is a very great advantage on any farm, both for lighting and power purposes. Where a small stationary engine is already installed on the farm it is not a very expensive business to put in a dynamo for generating electricity.

It is not possible here to go very fully into electrical theory, nor is it necessary, since the knowledge requisite for running a small farm plant is not very great. If the main principles are known the operator can usually get along very well by exercising common sense and following the maker's instructions.

The dynamo depends for its action upon the fact that a magnet moving in a coil of wire sets up an electric current in the wire. The reverse is also true, and in the dynamo an armature, heavily wound with coils of wire, is rotated with a series of electro-magnets. The current, which begins to flow as soon as the armature is set in motion, is led to the commutator,* from which it is collected in a steady stream by carbon " brushes " or blocks, to which the end of the cable is attached. Every current must make a complete circuit if it is to flow at all, and consequently one set of brushes leads to the external circuit, while the other receives the current returning from the outer circuit.

The wires through which the current flows are known as conductors. Certain materials, such as metals and

* The direct current (D.C.) generator, the type generally used for farm work, is described.

carbon, will act as conductors, while others, like wood, porcelain, and rubber, will not. The latter class are known as insulators, and are useful for building up round a conductor to prevent the current escaping from it. Thus the majority of electric cables are covered with an insulating layer of rubber.

In order that a current shall flow an electromotive force must be present to bring it about. This is measured in volts and corresponds to a head of water. Normal voltages for farm sets are 25, 50, or 100. The quantity or " volume " of current flowing is measured in amperes, referred to as " amps."

All conductors offer some resistance to the passage of a current, and this is measured in ohms. When an electromotive force (E.M.F.) has to overcome resistance in forcing a current through a conductor it becomes weakened and the voltage drops. For any given substance employed as a conductor, the resistance varies according to its dimensions. A long, thin conductor thus offers much more resistance than a short thick one. Added to the normal resistance is the fact that while a current is passing the conductor becomes heated, and increase of temperature still further raises the resistance. Thus it is important to provide conductors of a liberal size in order to obviate undue voltage drops.

All circuits are protected from the effects of an overload by fuses. A fuse is a short length of soft wire which forms part of each circuit and is placed in an accessible position. It will carry a current which is safe for that particular circuit, but should too heavy a current be taken through the wire the fuse will melt and break the circuit, thus indicating the overload.

The current generated by the dynamo and led through the outer circuit can be made to do useful work in lighting, or driving electric motors. The unit of electrical power is the watt, obtained by the product of the effective voltage and the amperage ; 746 watts equal 1 h.p. As the watt is such a small unit, the more convenient kilowatt (kw.),

equal to 1,000 watts, is usually employed in practice. For lighting purposes one kw. will keep about sixteen ordinary carbon filament lamps of sixteen candle power each burning at full strength for one hour.

The filament of the lamp offers a high resistance to the passage of the current, and becomes intensely hot and incandescent. The current used is of course expended in overcoming this resistance. Hence a filament which becomes incandescent while offering the least resistance is the most economical. Gas filled lamps consume the least current, and the latest types take only one-half watt per candle power.

It is usually advisable to employ a battery of accumulators in conjunction with a generating set, especially for lighting purposes. As a result of certain chemical reactions, the battery gives the effect of electrical storage, and enables a steady current to be available at times when it might be inconvenient to run the engine for driving the generator. Furthermore, the generator and the battery (when charged) can be used together to supply a current of double the usual amperage for special work, or heavy loads.

The care of accumulators and the system of charging and discharging is too wide a subject to be dealt with here and should be given careful study by anyone operating a plant, since the battery costs about one-third of the total outlay on a lighting set and is very easily damaged by careless handling.

An electric motor is practically a generator operating the reverse way, current being led in and causing the armature to revolve. Such motors are very economical and show an efficiency of about sixty per cent. They are useful for all kinds of belt work, and particularly for driving separators, shearing machines, and light barn machinery.

CHAPTER XXIV

THE FARM WORKSHOP

ALTHOUGH farm machinery is now on the whole very reliable, breakdowns may occur through accident or careless handling, and it is very necessary that the operator should be able to carry out at

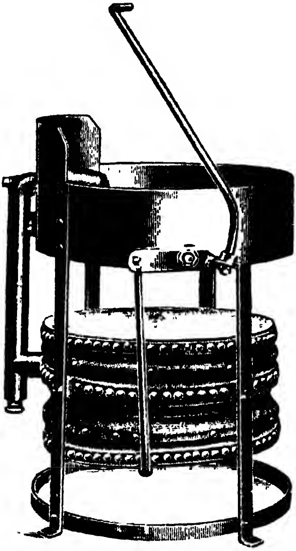


FIG. 138. A useful type of portable forge

least the minor repairs. Skill in the use of tools is gained

only from instruction by a skilled mechanic and practical experience. However, it will be useful here to deal with the commoner tools needed on the farm and the work that can be done with them.

In the chapter on Methods of Construction some indication has been given of the various processes involved in the working of metals. Generally speaking, most of the components of farm implements are made by casting and forging. The former is not a process which can be carried out on the farm, but a great deal of the repair work is done by the latter, which also involves treatment of the work by heat.

The smith's outfit consists essentially of a forge, an anvil and a hammer. A portable forge of the type illustrated (Fig 138) is the most suitable for farm repair work.

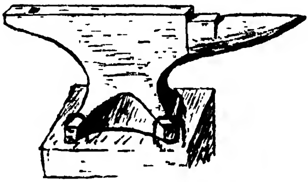


FIG. 139. The smith's anvil

When the forge is in use, the hearth will be covered to a little above the blast hole with dead coal, and the back will be banked up with green (unburnt) coal. To start the fire, a space round the blast hole should be cleared out and filled with oily rags, shavings, etc. This is lightly covered with fresh coal drawn from the back and the fire started, the bellows being gently worked. As the fire begins to draw, more coal is raked over it and the amount at the bank made up. By drawing coal from the back of the hearth, to keep up the fire, no green coal is directly burnt. Smoke and flame are thus avoided and a clear fire maintained.

The shape and extent of the fire are determined by the

work in hand. For small work a narrow fire is aimed at, stretching out straight from the blast hole, and this is secured by loosening up the fuel from the front and thus producing a draught in the desired direction. For heating large surfaces a larger, round fire must of course be maintained. A clean fire is always to be aimed at, and any clinker which may form must be thrown out.

Most of the anvil work is done on the flat top, but the rounded end is used for making rings and similar articles. An upright, fixed chisel or hardy is held in the square hole for much of the cutting, but when not required it should be hung out of the way on the anvil box. Other tools for shaping can be held in the same slot.

For general use, a hand hammer, of the shape shown (Fig. 140) is required, but for heavy work a sledge must

Fig. 140. Engineer's hammer

also form part of the equipment. Skilful use of the hammer is the essential part of smithing. A good, strong haft of the proper shape is necessary, and the operator should hold it near the end, aiming at getting a clean blow each time. The strength of impact depends, of course, on the work in hand.

Heated metal is held, when being worked, by means of long handled tongs, of which a good set, capable of holding flat and round iron of all sizes, should be kept handy.

Alongside the forge a water trough is required, and this should be large enough to allow any object of ordinary size to be immersed in the water for cooling.

As an example of the use of these simple forge tools

may be given the method of forming a right angle bend in a piece of flat iron. The point at which the bend is to be made is first marked with a centre punch and the iron is then laid in the fire, in such a position that the region

Fig. 141 One type of smith's to

Fig. 142. Centre punch

on each side of the marks becomes heated. When the iron is approaching white heat it is withdrawn and the ends are cooled in the water, so that only an inch or two is left glowing on each side of the marks. One quick dip

of each end is all that must be given in the way of quenching. The heated part is then laid over the edge of the anvil and the end knocked down, till the angle is roughly formed. The whole is then trued up on the flat of the anvil and the truth of the angle tested with a set square.

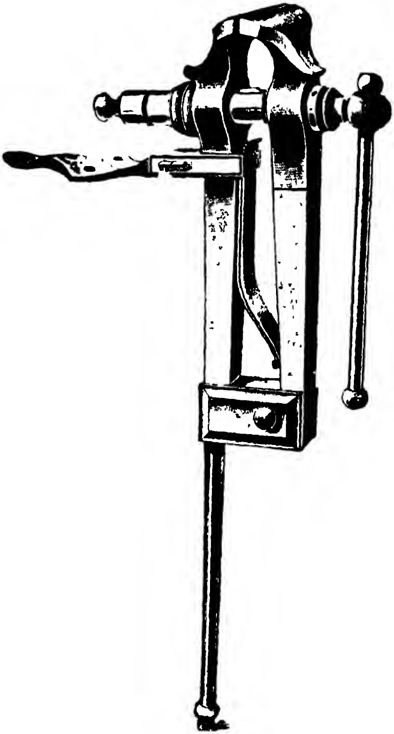


FIG. 143. A good type of vice for general use.

A good deal of bending and shaping is done with the help of the vice, of which a good general purpose type is shown. For example, if the right angle bend described above were required to have a sharp corner, the heated

iron would be placed in the vice with the mark just above the jaws, the upper end being then bent over and hammered down.

Setting and twisting is also done to a large extent with the aid of the vice. To twist a piece of iron on the flat the part is first heated; one end is then secured in the vice, and the other gripped with the tongs or a spanner and twisted to the desired extent.

The swage block is used for making circular offsets in a bar and other work of a similar nature. The heated iron is laid over a groove, of which the internal diameter corresponds to the desired external measurement. The iron is then forced into conformity with the curve by means of a mandrel or round piece of steel, which is hammered down on to the iron.

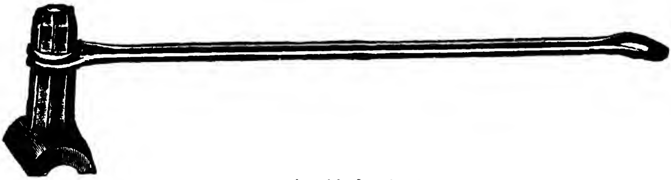


FIG. 144. Smith's hand swage

The same swage block is also usually drilled with a number of holes of varying sizes. These are useful in punching holes through a piece of work. The centre of the hole to be made is marked with the centre punch and the surrounding metal raised to white heat. A small punch is then driven through the iron at the spot marked, the punch being frequently cooled to prevent its becoming overheated and softening. When a small hole has thus been opened on the anvil the work is again heated and laid over a hole on the swage block. This allows of the hole being further expanded by means of successively larger punches to any desired extent.

Any bar of iron or mild steel may be appreciably lengthened, at the expense of its thickness, by drawing down. This process consists of hammering out the heated metal

on the anvil, directing the strokes towards the end of the bar. With round iron care must be taken to preserve the correct shape, which may be done with the help of a swage.

The alternative method of lengthening a bar is to weld an extra piece on; and this does not take away from the thickness. The success of the weld depends on the skill of the operator and the quality of the metal, some inferior irons being almost impossible to weld, as they burn before coming to welding heat. When welding bars end on, it is advisable to upset the two ends first. This is done by heating the ends and pounding the extremities or jumping them on the anvil, thus causing them to thicken up.

The two ends to be joined are then lipped, notched, and placed in the fire together, so that they may come to welding heat together. For the actual operation an assistant is required. The determination of the correct heat is a matter of experience, but it is indicated by an intense white heat and the appearance of the metal, which is commencing to fuse and go into a state of flux. Directly the right point is reached, the work must be whipped out of the fire, swung rapidly through the air to dislodge clinker and burnt particles adhering, and the two ends dabbed together on the anvil. The hammer is immediately brought into play to pound the two pieces together, the work being turned from side to side.

If the operation has been carried out at the right temperature the two pieces will be firmly united as a homogeneous mass, and the join must be well worked and trued up with hammer. The process is not a difficult one in itself, but requires experience, and no opportunities should be lost of practising with odd scraps of material.

Cooling or quenching heated parts should never be done indiscriminately. Any part made of iron or steel which is suddenly quenched becomes hardened, and has a tendency to be brittle, unless it is reheated and allowed to cool slowly. For this reason work should not be cooled suddenly unless it is required to be hard.

Quenching has a definite purpose when it is desired to

temper steel for making tools, such as chisels, punches, and the like. The process of tempering consists in raising the work to a dull cherry red. It is then dipped for an instant at the point and withdrawn, when it is rubbed down with a piece of gritstone, the strokes being made towards the edge or point. While this is being done, a change in colour will be noticed, as the heat travels towards the point. First the colour will be yellow, followed by a range of others in succession. If the tool is quenched right out at any particular colour it will have a definite

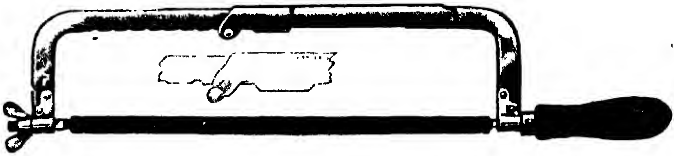


FIG. 145. Adjustable hack saw

hardness, and the accompanying table shows at what colour to quench for any particular purpose.

Blue	Screw drivers.
Pale Blue ..	Cold setts for wrought iron.
Dark Purple ..	Axe blades; chisels for steel and cast iron.
Light Purple ..	Drills.
Dark Yellow ..	Drifts and Punches.
Straw Yellow ..	Scrapers, hammer faces, etc.

Following on the forge work, a certain amount of fitting has to be done, and for this a further range of tools is required. For example, hammers of a lighter type than those used at the forge are needed for fitting and riveting.

Cutting is done by means of a hacksaw, one type of which is illustrated (Fig. 145). A hacksaw should have a sufficiently rigid frame and a good tightening device for the blade, which is put in with the teeth pointing away from the handle. When cutting, the strokes should be

cleanly made for the full length of the blade. Always avoid a jerky action and too much pressure, which are liable to cause a broken blade.

Single or double blades are obtainable, and with teeth of varying fineness. Coarse toothed blades are marked for cutting soft metals, and fine for mild steel, iron, etc.

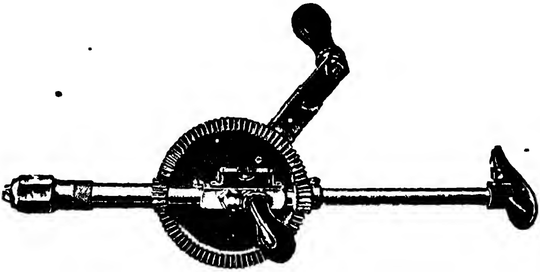


FIG. 146. Breast drill for small work

A frame taking blades ten inches long is suitable for general work, and a good stock of spare blades should be kept.

Where it is not desirable or possible to punch holes through a piece of work the drill is used. This is in fact the method more generally adopted. It has the effect, however, of weakening the part drilled to an extent deter-

FIG. 147. Morse bit

mined by the amount of metal removed, and in some cases this is a disadvantage.

Drills are of widely varying types. For small work, the breast drill is needed. This is operated by hand and takes bits up to about three-eighths of an inch in diameter. The size of hole which can be drilled is limited by the hardness of the metal, its thickness, and the time available in which to do the job.

Wherever any amount of work is to be done it will pay

to instal a pillar drill. This may be hand- or power-operated, but in either case enables the work to be easily and expeditiously done. With this type of drill, holes up to about one and a quarter of an inch diameter can be bored, but for these larger sizes a power drive is desirable.

In using the drill, particularly if power driven, care must be taken not to put on too much pressure, or, in other words, not to feed too fast, as this will cause hard running, overheating, and frequently breakage of the drill. The work must always be accurately centre punched, so that the drill enters correctly.

Morse bits are the best for general work. These are fluted, and have two cutting edges above which the drill narrows, to give clearance. It is important to have the cutting edges sharp, and in trueing up the drills on the grindstone care must be taken to keep the original angle, which is about 59°, and the cutting edges should then be straight. When cutting holes of large bore it is desirable to drill a small pilot hole first.

After any work has been cut or shaped, it usually has a rough surface left, which must be got rid of. A range of good files is an important part of the fitter's equipment, and at least half a dozen of different types are needed. Files are classified according to whether they have one or two series of teeth cut on them, as single or double cut. Of each class there are six grades, but of these for general farm work the rough, bastard, and smooth double cut will only be needed. A flat file of each grade mentioned is necessary, while several square and round ones are also required, more than one size of the latter shape being included.

In using a file the tool must be kept flat on the work and any tendency to see-sawing resisted. The pressure should be applied during the forward stroke and relieved on drawing the file back. New fine cut files should not be used on soft metals, as the teeth will quickly become clogged up.

It is frequently necessary to cut screw threads in the

course of repair work, and if possible a good set of Whitworth stocks, dies, and taps should be kept, as this is the standard English thread. These will meet practically all requirements connected with machinery made in this country, but with regard to foreign makes other threads are likely to be found.

The dies, usually made in two halves, are of all sizes, for different threads and sizes of material. They are held in the stock by means of which they are turned round and round on the work, pressure being gradually applied by means of the screw in the stock. The dies are provided

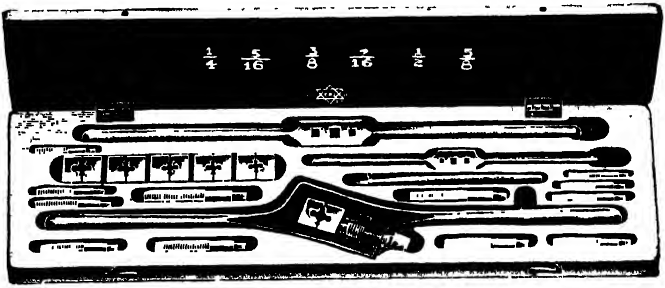


Fig. 148. Set of stocks and dies

with cutting edges corresponding with the grooves in the finished thread, which they cut as they are turned around the metal. When the thread approaches completion, the nut to which it is being fitted must be tried on from time to time.

Internal threads, such as that inside a nut, are cut by means of the taps. The thread is usually started by means of a taper tap and then finished out with a plug tap of the required size.

It is important to discriminate between metal working tools which must be lubricated when in use and those which must not. Of those mentioned above, the drill must be well lubricated when cutting wrought iron or steel, but not when at work on cast iron. The oil-can should

also be kept in full use on threads which are being cut. Oil must never be used on a hacksaw or a file, as it will prevent these tools from cutting.

A great deal of work can be done by means of a lathe, but the use of this machine is such a wide subject that it cannot be dealt with here. Moreover, it would not pay to instal one on the farm, unless there were sufficient repairs on machinery such as engines and tractors, which require accurate work, to justify the outlay.

Bolts and nuts, which are used for holding component parts together, are being continually handled in the course of machine fitting. When dismantling an implement every

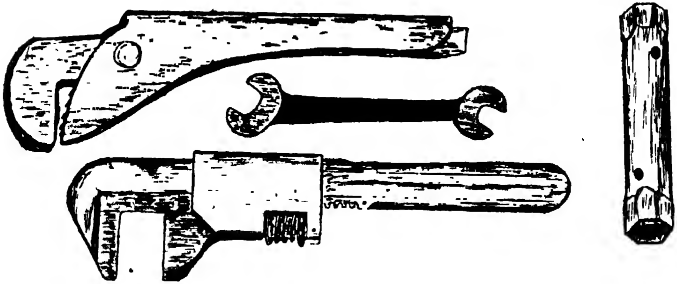


FIG. 149. Footprint wrench; set, adjustable and box spanners

bolt taken out should, after the part it held has been removed, be slipped back into the hole and the nut put on. This precludes the possibility of the bolt being lost or put back in the wrong place.

The proper use of the spanner for adjusting nuts is important. Spanners of the set type should be used whenever possible, the adjustable type being kept for emergencies. The two chief points with regard to the spanner are, first, to use one which fits the nut, and second, never to use a spanner as a hammer. Careless handling of a spanner usually means barked knuckles, a damaged spanner, and, if in the neighbourhood of the sparking plug of an engine, often results in a cracked porcelain.

Lock nuts are put on over the ordinary nut to prevent the latter working loose in situations where much vibration is encountered. Washers are also employed for the same purpose, taking up any play on the underside of the nut. Spring washers are the most generally useful for farm work.

When tightening up a nut, the last strokes should be made firmly and steadily, and the hammer should not be used to get extra pressure. When bolting up a casting, it is vitally important to draw up all nuts evenly, a little at a time, as otherwise the casting may be fractured. This may also occur if excessive pressure is put on. A further point in putting on a nut is to avoid getting the threads crossed.

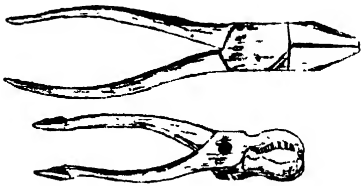


FIG. 150 Wire cutting and gas pliers

Where two parts are to be permanently joined together it may be preferable to use rivets instead of bolts. Such an instance is the knife section of a mower sickle. Should a section break or wear out it is necessary to remove the broken section and replace it.

The rivets must be first got out by cutting off the heads of the rivets with a chisel and hammer and punching them out with a small round punch. A new section is then put in place and two new rivets put in. The sickle is laid on the anvil (or a suitable substitute) with the rivet heads down. A small flat paned hammer is used for the riveting operation, which consists in spreading the point of the rivet to cover the hole and form a second head. The point is first burred over with the pane of the hammer and the

job completed by a careful tapping, to spread the rivet in the hole, and neatly work down the burred head.

A soldering outfit is required for repairs to copper pipes (such as engine fuel pipes), tanks, etc. A copper bit of a good size should be obtained, together with some sticks of solder (an alloy of two parts of tin to one of lead), and a suitable flux. The best for the repair shop is "killed" spirits of salt (hydrochloric acid), which can be made as follows: a small stone jam jar is half filled with the acid, and zinc (granulated or strip) is dropped in until all effervescence ceases and a small amount of zinc lies at the bottom.

Parts to be soldered must first be cleaned thoroughly, especially from oil. The copper bit should be carefully heated (not to redness) and cleaned with a file. It is then quickly dipped into the flux and then tinned, by holding a stick of solder to its surface until it is properly coated. The work is then wetted with the flux and the solder run on to it with the help of the bit, which may be reheated if necessary. If all is in order the solder will flow freely on the work and follow the bit.

When putting a patch on a tank, for example, the surfaces of the patch and the parts around the hole must be cleaned and tinned. The patch is then laid in place, with some flux run under it, and the heated bit held on the patch till the two tinned surfaces unite.

Copper pipes are led into tanks through a screwed union, the end of the pipe having a nipple which stops it from slipping out of the union and enables a piece of packing to be screwed firmly against the pipe to prevent leakage. To fix these nipples in place the end of the pipe is first tinned. The nipple is then heated and the tinned end of the pipe pushed into it, when a satisfactory joint should be made. It should not be forgotten that the unions must be slipped on to the pipe before the nipples are fixed.

Those who have the care of a four-stroke engine will from time to time have to undertake the job of grinding in the valves. This is quite a simple operation if done the

right way. The engine having been dismantled so as to expose the valves, the springs should be carefully removed, and the valves taken out and examined. If the seats are at all pitted, grinding will be necessary.

The valves, after being cleaned up and having any carbon deposit removed, are replaced on their seatings, on which a little valve grinding paste, mixed with oil, has been rubbed. A carpenter's brace, with a screw-driver bit, is then used to rotate the valve on the seat. This should be done quite lightly; and at the end of eight or ten revolutions the valve should be lifted and turned a little backwards. This prevents any piece of grit wearing a groove in the seating. The valve should be finished off by rotating with a little plain oil, after wiping away all the grinding paste. When finished it should have a dull, flat surface, showing no pits or grooves.

In some cases two holes are sunk in the valve head instead of a slot, and in such cases a special bit is required. After grinding is finished all the parts must be carefully cleaned, especially the valve stems and guides.

When valve grinding is done, any carbon deposit on the cylinder head and piston should be removed by careful scraping. A heavy deposit invariably causes a bad knock, due to pre-ignition, and decarbonizing is a regular item in engine maintenance, occurring more frequently with paraffin than with petrol engines.

APPENDIX

USEFUL DATA

HORSE POWER CALCULATIONS FOR I.C. ENGINES

INDICATED H.P. is found from following formula :—

$$1 \text{ H.P.} = \frac{PLAN}{33{,}000}.$$

P = mean effective pressure in lb. per square inch.
L = length of stroke in feet.
A = cross sectional area of piston head in square inches.
N = number of power strokes per minute.

Brake horse power is determined by test, generally using the Prony brake.

An adjustable wooden brake shoe is placed around the flywheel of the engine to be tested. It has an extended arm, which is supported by a spring balance. The downward pull of the brake arm on the balance is read with the engine at rest and the brake loose = W^1. The engine is started up and with the aid of a revolution counter is braked down till running steadily at the required speed, when the pull on the balance is again read = W^2. $W^2 - W^1$ = effective load = P. The actual brake horse power is then calculated from the formula

$$\text{B.H.P.} = \frac{2\pi rnP}{33{,}000},$$

where

r = effective radius at which brake load acts, in feet.
n = r.p.m.
P = effective load in lb.

Table 17

HORSE POWER TRANSMITTED BY SHAFTING

Diameter of Shaft	100 R.P.H.	150 R.P.H.	200 R.P.H.	250 R.P.H.	300 R.P.H.
$1\frac{3}{4}$	6	8·9	11·9	14·9	17·9
2	8·9	13·3	17·7	22·2	26·6
$2\frac{1}{4}$	12·6	19	25	31	38

DISTANCE APART OF BEARINGS FOR SHAFTING

Centre to Centre.

Diameter of Shaft in inches	feet	inches
$1\frac{3}{4}$	7	3
2	8	0
$2\frac{1}{4}$	8	6

HORSE POWER TRANSMITTED BY BELTS

Feet Per Minute	Single Leather or 4-ply canvas
100	0·15
200	0·30
300	0·45
400	0·61
500	0·76
1,000	1·51
1,500	2·27
2,000	3·03
2,500	3·79
3,000	4·50
3,500	4·90
4,000	5·08

Permissible working stress—50 lb per inch width.

WORKING CAPACITY OF VARIOUS IMPLEMENTS

		Acre per hour
Plough, 2 furrow, tractor	..	$\frac{1}{2}$
Plough, 3 ,, ,,	up to	$\frac{3}{4}$
Cultivator, 11 tined tractor	..	1
Broadshare, tractor	..	$\frac{3}{4}$
Skim Plough, tractor	..	$\frac{3}{4}$–1
Disc Harrow (double), tractor	..	1
Drill, 15 coulter	..	$1\frac{1}{2}$
Artificial Distributor	up to	2
Mowing Machine	..	$1\frac{1}{4}$
Binder (cutting all round)	..	2

RATES OF TRAVEL IN MILES PER HOUR AND FEET PER MINUTE

M.P.H. equals	Feet per minute
1	88
$1\frac{1}{4}$	110
$1\frac{1}{2}$	132
$1\frac{3}{4}$	154
2	176
$2\frac{1}{4}$	198
$2\frac{1}{2}$	220
$2\frac{3}{4}$	242
3	264
$3\frac{1}{4}$	286
$3\frac{1}{2}$	308
$3\frac{3}{4}$	330
4	352

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